Chemical & Process Engineering

Vol. 36, No. 6 **CONTENTS** JUNE 1955

TOPICS OF THE MONTH 195

Chemical Engineering Review: SIZE REDUCTION *by R. V. Riley, Ph.D., B.Sc., F.I.M.* ... 199

AIR-POLLUTION CONTROL—REPORT ON INTERNATIONAL CONGRESS *by R. W. Moncrieff, B.Sc., F.R.I.C.* 203

FERTILISER WORKS SITE CONTAMINATION ... 207

THE WIDENING FIELD OF CHEMICAL ENGINEERING *by Sir Harold Hartley, K.C.V.O., F.R.S.*... 208

SOME CHEMICAL ENGINEERING PROBLEMS OF THE IRON AND STEEL INDUSTRY *by A. H. Leckie, Ph.D., F.R.I.C., A.M.I.Chem.E.* 211

ORE DRESSING RESEARCH IN INDIA, 1954 ... 215

BRITISH STANDARDS 216

RUMANIA'S CHEMICAL INDUSTRY 217

THE FUNCTIONS AND EDUCATION OF THE CHEMICAL ENGINEER IN EUROPE—REPORT ON O.E.E.C. CONFERENCE—2 218

PLANT AND EQUIPMENT:
Cam-operated programme controller; Direct-reading pH meter; Swarf separator; Centrifugal acid pump; New diaphragm pump; Infra-red process control; Removing and replacing heat-exchanger bundles 224

NEW PRODUCTS IN BRIEF 226

PERSONAL PARAGRAPHS 227

Aluminium Centenary Feature: BIRTH OF THE ALUMINIUM AND SODIUM INDUSTRIES IN FRANCE AND THE MIDLANDS *by M. Schofield, M.A., B.Sc., F.R.I.C.* 228

BRITISH PATENT CLAIMS 231

WORLD NEWS:
From Great Britain, Belgium, Gold Coast, Spain, Chile, Italy, Philippines, Uganda, Pakistan, Norway, Germany, Denmark, Colombia, India, United States 232

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A Healthy Chemical Plant Industry

IF any proof should be needed that a great chemical engineering industry is now firmly established in Britain, it would be found in the fact that in the past six years the British Chemical Plant Manufacturers' Association has more than doubled its size. This impressive growth is proudly but soberly recorded in the Association's annual report for 1954, a year which saw the chemical plant industry working under conditions of freedom from controls which it had not enjoyed since 1939.

A number of expansion schemes were completed or further developed which greatly increased the productive capacity of the industry. As a result, chemical plant manufacturers were able to quote much improved deliveries. Another pleasing feature is the further increase in collaboration between chemical and chemical plant manufacturers in connection with large capital projects which must react to the long-term, as well as the immediate, benefit of both industries.

The demand from overseas for capital equipment continued buoyant throughout the year and chemical plant exports, in common with those of any other British engineering products, were higher than in 1953. This increase was achieved in spite of increased competition and was assisted by improved conditions at home. Export business of chemical plant and allied manufacturers in 1954 amounted to 24,646 tons against 25,436 tons in 1953 and 22,112 tons in 1952, and a value of £9,570,000 against £9,150,000 in 1953 and £7,460,000 in 1952.

The joint committee of the Association of British Chemical Manufacturers and B.C.P.M.A., which is investigating the need for, and possibilities of, a greater measure of standardisation and simplification of chemical plant and equipment, made considerable progress during the year. Also, in view of the similarity of much chemical plant and petroleum equipment, the Association, on the recommendation of this joint committee, asked the British Standards Institute that work of the various chemical engineering and petroleum engineering committees should be properly co-ordinated to avoid duplication. The need for such co-ordination was accepted by the Chemical Engineering Industry Standards Committee of the B.S.I. and the question is to be reviewed by the Institution. B.C.P.M.A. is strongly represented on this committee, whose chairman is Mr. W. R. Beswick, a past chairman of the Association.

B.C.P.M.A.'s annual report strikes a less happy note when it mentions the courses for the Higher National Certificate in chemical engineering. That the chemical plant industry has not taken more advantage of the H.N.C. courses continues to be a source of disappointment. This is despite the fact that figures obtained in an enquiry among chemical plant and allied manufacturers show that there is a considerable and continuing demand for chemical engineers in that industry.

Another matter mentioned in the B.C.P.M.A. report is the plan for a combined exhibition of chemical plant

and petroleum equipment, sponsored by B.C.P.M.A. and C.B.M.P.E., that is scheduled for May or June 1958.

Britain behind in chemical technology?

SPEAKING at the annual dinner of the Graduates and Students Section of the Institution of Chemical Engineers, held in Birmingham recently, Mr. J. Wilson, Principal of the Birmingham College of Technology, said that after studying productivity methods in the United States and Germany on recent tours he had come to wonder whether Britain was 'living in a fool's paradise, and in need of a good shaking up.' While Britain still seemed uncertain about theories on higher productivity, the Germans and Americans were approaching the problem realistically and factory progress in Germany had become 'quite frightening.'

Both Germany and the United States were training thousands of chemical engineers and technicians each year. The Birmingham College of Technology planned to help training in this country by introducing special 'sandwich' courses on chemical engineering, designed to be complementary to university courses, rather than competitive. It was pointed out that Britain needed a more enlightened outlook towards chemical technology and Mr. Wilson commended the policy of the Institution, which went beyond the simpler issues of pure chemistry and engineering and included the practicalities of industrial management problems and techniques.

Another speaker, Mr. R. J. Kingsley, said that although Britain is once again reasonably prosperous its industry is still far too dependant on America and other sources for 'know-how.' It had the ideas, and probably sufficient university-trained people, but needed more of the 'non-commissioned officer' type of technologist if it was to stand on its own feet.

Mr. Kingsley also considered that some change should be made in the country's investments policy. More risk capital of the kind available in other countries should be available.

Measuring 100 particles per second

A DEVICE known as an *Aerosoloscope* has been developed by Dr. N. E. Alexander, of the Chemical Corps of the U.S. Army. Intended to give instant warning of enemy germ warfare attack, it measures and counts microscopic particles—one at a time—at the rate of 100 per sec.

Such an instrument will not only be helpful to scientists analysing the contaminated air in cities, but also to industries in which pigment particles have to be measured and all organisations concerned with particle size control.

Airborne particles ranging in size from 1 to 64 microns are stated to be counted by the *Aerosoloscope* 1,000 times faster than by ordinary methods, while the instrument is claimed to be more accurate and capable of modification to measure particles smaller than 1 micron.

Each particle passing through the machine is individually illuminated. Reflection caused by the illumination is detected by a photomultiplier tube and, as large particles reflect more light than small ones, the tube, in conjunction with other electronic apparatus, is able to determine the size of each particle.

Evaporation processes and fuel efficiency

'LOOK after the sensible heating and the evaporation will take care of itself.' This was recently offered by Sir Oliver Lyle, O.B.E., as a useful maxim to follow in any factory where there is evaporation. He was speaking at a recent conference on fuel efficiency, in London, organised by the National Industrial Fuel Efficiency Service and the Combustion Engineering Association, and he described how, at the Tate & Lyle sugar refinery, they had saved at least 60 tons of steam per 100 tons of sugar refined. He gave figures which showed that the saving was some £189,000 p.a.

This truly remarkable result was achieved by about 16 different projects, the latest of which was put to work about two years ago and was described by Sir Oliver in some detail. We present this useful example of steam efficiency, which would also seem to be applicable to smaller factories, in Sir Oliver's own lucid terms, as follows.

The refining of sugar is carried out with the sugar in water solution. The first process is mechanical filtration through filter presses with a filter aid to remove the insoluble impurities. The next process is the removal of the colouring matters and some of the soluble salts by adsorption on bone charcoal. The final purification is by recrystallisation, which leaves behind those soluble impurities that were not removed by adsorption and yields a solid marketable sugar.

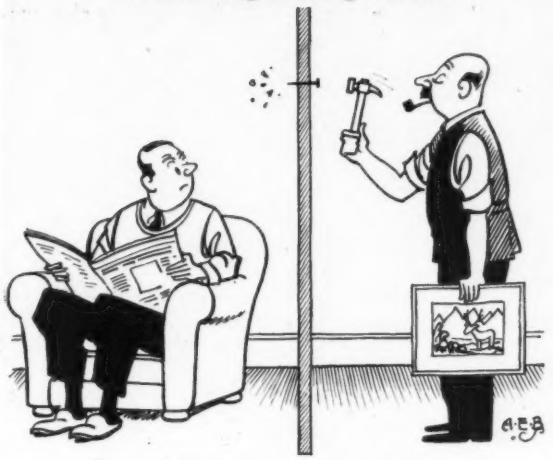
It is impossible to carry out filtration on a solution with less than 32% of water without raising the temperature so much as to form colour and destroy sugar. To get dry crystals all the water must eventually be evaporated.

The evaporation is carried out in vacuum pans at a vacuum of between 20 and 26 in. The evaporation and crystallisation is done in batches that take about 2 hr. and the vacuum has to be continually varied to control the rate of crystallisation. The vacuum must be kept as high as possible to keep the boiling temperature as low as possible to minimise deterioration. The low-temperature vapour from the vacuum pans is condensed in jet condensers with river water, but on its way it passes through surface condensers where it heats all the incoming town water to about 140°F. This uses only a small part of the heat thrown away in the vapour.

Although the filtration and decolorising processes can only be done on a liquor containing about 32% water, the vacuum pans could be fed with a liquor containing only 26% of water without upsetting the crystallising process. The difference between liquor of 32% water and 26% water represents 12 tons of water per 100 tons of sugar.

So the evaporation is split into two parts: reducing

Comical Engineering Terms



"WALL THICKNESS MEASUREMENT"

the water in the liquor from 32 to 26% and the crystallisation of the sugar from the liquor with 26% of water. The preliminary evaporation can be done at the high temperature of 200°F., provided the liquor is only kept at this temperature for a few minutes—otherwise it would deteriorate.

So the liquor with 32% water is put into an evaporator with a very small retention volume working under a vacuum of 11 in. The liquor is then sprayed into an empty vessel at 20 in. where it cools instantly by flash.

The vapour from this evaporator is hot—about 190°F.—and has good heating power. It is used to heat all the incoming town water from 140 to 175°F. to heat various liquors and syrups and to provide the heat needed to dissolve the raw sugar in water. These heating jobs had previously been done by live steam and used all the vapour from the evaporator amounting to 12 tons per 100 tons of sugar. So that the whole of this preliminary evaporation has been done for nothing.

This plant is, therefore, saving 12 tons of steam per hour, worth over £37,000 a year.

Oxygen flash smelting of copper

DETAILS of the new oxygen-flash smelting process for treating copper concentrates—one of the world's first commercially successful processes for smelting fine sulphides in suspension—were recently revealed by the International Nickel Co. of Canada Ltd. The method is now being used by Inco to treat all of its copper sulphide concentrates. In 1954 the company delivered more than 250 million lb. of refined copper.

Under development since 1945, the process recently completed its first full year of successful operation. It has reduced Inco's copper smelting costs and, in addition, the use of oxygen for smelting has resulted in the production of a high-quality furnace gas from which liquid sulphur dioxide and sulphuric acid are made.

Details of the process were outlined in a paper presented at the annual meeting of the Canadian Institute of Mining and Metallurgy by C. E. Young of the smelter operating staff. Development of the new process involved the co-operative efforts of the International Nickel Co., Canadian Industries (1954) Ltd. and the Canadian Liquid Air Co. Ltd. The process eliminates the fuel normally required for smelting and permits large-scale output by Canadian Industries of liquid sulphur dioxide produced from the flash smelting furnace gases. The low-cost oxygen which makes Inco's process economically possible is produced by a tonnage oxygen unit known as an *Oxyton*, which was built for Inco by Canadian Liquid Air. This unit produces 325 tons of 95% pure oxygen every 24 hr., corresponding to $2\frac{3}{4}$ billion cu. ft. p.a. of oxygen, or three times the production of all the cylinder oxygen plants in Canada.

The conventional treatment of copper sulphide concentrate involves smelting in reverberatory furnaces with pulverised coal or other fuel, with or without prior roasting. The matte formed contains a large proportion of iron sulphide, which is subsequently removed by oxidation and slagging in Bessemer converters. The converter slag thus formed is returned to the copper reverberatory furnaces. The copper sulphide remaining is 'blown' to blister copper, which is then refined for commercial use. At Inco, the former practice was to wet charge the copper concentrates with flux to reverberatory furnaces and smelter with pulverised coal.

In the new flash smelting process, finely divided copper concentrates and flux are dried and injected with oxygen into the preheated smelting furnace to produce matte, slag and a gas containing about 75% sulphur dioxide. In the furnace, the oxygen combines with some of the sulphur and iron of the chalcopyrite (copper-iron-sulphide) to form sulphur dioxide and iron oxide. The heat of the reaction is sufficient to melt the residual copper-iron sulphide to form a matte, and the iron oxide combines with the siliceous flux to form a slag. An important feature of the Inco process is a novel method of cleaning the copper-rich slag by flash smelting pyrrhotite at the skimming end of the furnace. The slag is showered with iron sulphide droplets which, in settling into the matte beneath, extract copper from the slag.

The flash smelting furnace gas is water scrubbed and treated by a wet Cottrell before it is converted into liquid sulphur dioxide by Canadian Industries. The production of liquid sulphur dioxide involves drying the cleaned gas with sulphuric acid, then compressing and cooling the gas to condense the sulphur dioxide. Using gas from this furnace and other smelter units, Canadian Industries last year produced approximately 70,000 tons of liquid sulphur dioxide for use by the Canadian sulphite pulp industry as well as about 65,000 tons of 100% sulphuric acid.

Inco's flash smelting furnace is 68-ft. long, 24-ft. wide and 17-ft. high at the ends, outside its steel casing. It has a smelting capacity of approximately 1,000 tons of dry solid charge daily.

Heavy chemicals in Finland

ELSEWHERE in this issue a contributor points out the salient features of the Rumanian chemical industry, which seems to be branching out in a great many directions in both the organic and inorganic fields. Another of Russia's neighbours—Finland—is treading more cautiously, for the small home market for chemicals there obliges manufacturers to concentrate on making products for which cheap raw materials are available in the country or which can be produced economically in relatively small quantities.

Some idea of the situation in Finland's heavy chemicals sector can be gained from the latest production figures available. Phosphate fertilisers head the list at 400,000 tons p.a., then follow sulphuric acid at 130,000 tons; nitrochalk, 40,000; caustic soda, 20,000; chlorine, 20,000; calcium carbide, 8,000; and sulphate of ammonia, 5,000 tons. Further down the list come ammonia, ammonium nitrate and zinc white, each of which stands at 1,500 tons p.a. These figures were quoted in *Chemische Industrie* by Dr. A. Metzner, who reports that a factory for producing 16,000 tons p.a. of nitrogen in the form of nitrochalk, ammonia and nitric acid, erected at Oulu in 1952 by the State combine 'Typpi Oy,' has been in full production since June 1953. The demand for nitrogen compounds exceeds the supply, and a further expansion of this branch of the chemical industry is planned.

Another State combine, 'Rikkihappo-ja Superfosfaatt tehtaat,' began 30 years ago to make sulphuric acid from the smelter gas and the sulphur concentrates of Outokumpu's metallurgical plants. The combine now possesses four sulphuric acid works, three of them using the contact and one the tower process and, in addition, three works making superphosphate and sulphate of ammonia.

Hydrochloric acid is made by 'Kymin Oy,' partly from hydrogen and chlorine, and partly as a by-product of the chlorination of organic compounds. The only manufacturer of calcium carbide is 'Kymin Oy.' Somewhat more than half the production of the Kuusankoski works is converted into acetylene and the rest into calcium cyanamide and chlorine derivatives of acetylene. 'Kymin Oy' is also the only manufacturer of sodium phosphates.

Caustic soda and chlorine are made electrolytically by two firms, the 'Finnish Chemicals Oy,' in a factory at Aetsä erected in 1938, and 'Kymin Oy' in a factory at Kuusankoski erected in 1927 and enlarged in 1935. Two other works were lost to Russia at the end of the war.

The Finnish Council for Industrialisation has suggested the erection of a new plant with a capacity of 15,000 to 20,000 tons of chlorine p.a., but it is not likely that these plans will materialise in the near future.

The production of caustic soda is taken up by the soap and paper industries. Eighty per cent. of the chlorine is used for bleaching cellulose, 18% for chlorinating organic compounds and 2% for sterilising water. A small quantity is used for making bleaching powder. Soda ash is not manufactured in Finland.

Propane from iso-propyl alcohol

DURING research on the polymerisation of propylene carried out in the Laboratory for Chemical Technology of the Technical University of Delft, larger quantities of pure propylene were required than the Dutch industry was able to deliver at short notice. It was therefore decided to produce propylene at the University on a semi-technical scale. Now, in industry, propylene is made from the gaseous mixtures obtained by the cracking of crude petroleum. These mixtures contain 10 to 30% of propylene, and fractional distillation yields a fraction consisting mainly of propane and propylene. The isolation of pure propylene from this mixture is difficult, and this method was therefore discarded in favour of the usual laboratory method: the dehydration of iso-propyl alcohol.

Out of the many catalysts that have been recommended for the preparation of propylene from iso-propyl alcohol, two were selected for large-scale experiments: a mixture of equal quantities of technical aluminium oxide and chemically pure calcium phosphate, compressed under a pressure of 150 kg./sq.cm. into tablets of 9-mm. diameter and 6-mm. thickness; and pure activated alumina in granulated form. The activated alumina gave a purer product and a better yield. It works better with iso-propyl alcohol than with normal propyl alcohol, one of the reasons why iso-propyl alcohol is preferred to the normal alcohol as raw material for the dehydration.

Very important is the choice of temperature, because aluminium oxide catalyses at various temperatures different reactions. At a temperature between 300 and 350°C. the dehydration occurs almost completely according to the equation: $(CH_3)_2CHOH = CH_3CH{:}\,CH_2 + H_2O$. At lower temperatures di-iso-propyl ether is the main product, and at higher temperatures various hydrocarbons, mainly methane, are formed.

The catalyst is placed in a vertical, electrically heated reactor, and iso-propyl alcohol vapour is fed into the reactor from above, whilst the products of the reaction are withdrawn from the bottom and cooled to 15°C. to separate the gas from water, unchanged alcohol, di-iso-propyl ether and acetone. The temperature of the reactor is measured by two copper constantan thermocouples at the top and bottom of the catalyst bed. The speed with which the alcohol vapour passes through the reactor is regulated by regulating the pressure of compressed nitrogen driving the alcohol from the storage vessel into the steam-heated evaporator.

The propylene is collected in gas holders and dried by passing it through a column which is 90-cm. long, has a diameter of 20 cm. and is filled to two-thirds with lumps of calcium oxide of 2 to 3 cm. diameter. The gas is then warmed to 60°C. and compressed under a pressure of 12 atm.

According to Dr. J. J. Verstappen and Prof. H. I. Waterman, who gave details of the foregoing method in *De Ingenieur* for September 3, 1954, the same apparatus has been used successfully for the preparation of ethylene by the continuous catalytic dehydration of ethyl alcohol.

SIZE REDUCTION

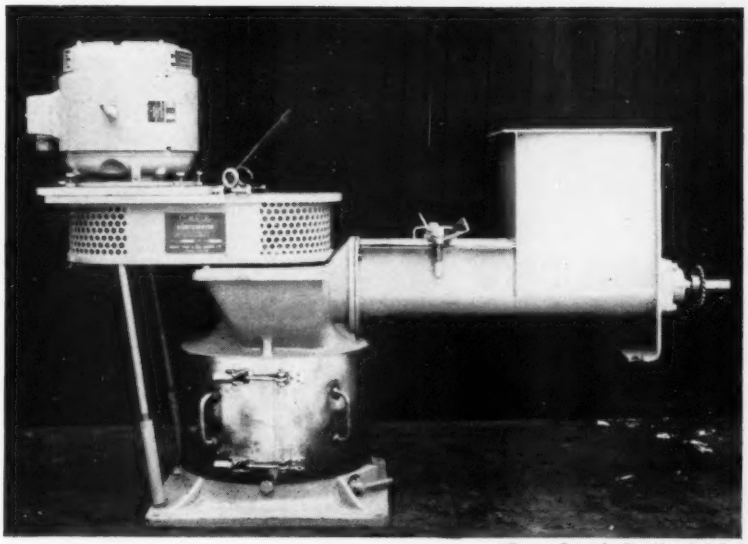
Scientific studies of crushing and grinding problems; primary and secondary crushing; fine grinding; new machines and techniques in industry; materials of construction

By R. V. Riley, PH.D., B.SC., F.I.M.

Theory and practice

ANOTHER year of activity in size reduction has brought little new in our understanding of the theory and fundamentals of comminution. Methods of scientific approach have, however, been applied to practical crushing and grinding problems. Zeisel,[1] working with a modified Hardgrove vertical annular ball mill, attempted to determine a quantitative expression of grindability for a number of materials. The actual work done in grinding was measured and the fineness of grinding of the product was determined by taking measurements on the surface area. He worked with a range of materials including cement clinker, limestone, blast-furnace slag, quartz sand, rock crystal, fluorspar, barytes, coke and coal. Tests in which the mill speed, loading and initial particle size were experimentally varied, showed that, of these factors, the initial particle size was most important and that, for any one material and set of mill conditions, a maximum ease of grinding was recorded for a given surface area weight ratio. The advantages of multi-stage grinding processes was demonstrated.

Schmid[2] worked on similar lines and related the relative ease of grinding to the physical and chemical properties of the grist. With cement clinker, the ease of grinding was inversely proportional to its resistance to impact. Clinker with a higher free-lime content was relatively more easy to grind than one with a higher alumina and titania content. A knowledge of the composition and physical properties of closely related materials enabled their relative grindabilities to be forecast. The grinding of cement clinker was studied also by Aichinger and Jordan,[3] who concluded that rapid grinding could be accomplished only with a graded feed in which the coarser particles should not exceed 10-mm. size. As a measurement of the work done in grinding, the specific surface of the particles was a better criterion than sieve grading. On the other hand, Hüttig *et al.*[4] determined a series of functions based on sieve analyses with which it was claimed to be possible to assess the progress of pulverisation.



[*George Scott & Son (London) Ltd.*

A typical combination of prebreaker and disintegrator designed for the reduction of whole pineapples to a pulp. The secondary discharge is variable and is controlled by the lever shown at the bottom right. The adjustment of this control results in more, or less, fibrous material being separated from the pulp. The hammers of the disintegrator run at 6,800 r.p.m. and all contact parts are in stainless steel.

J. Taylor[5] determined for a number of ores that simple crushing of lumps produced particles which fitted the normal Gaussian distribution. In general, the pattern of the breakdown was independent of the starting size and the reduction ratio.

Levenson[6] studied the process of crushing in a jaw crusher and Fairs[7] described a method of relating the performance of commercial grinding mills to that of a laboratory impact crusher operating under free crushing conditions. This meant that a laboratory test on a unit impact crusher permitted a prediction to be made of the works performance of certain brittle minerals when crushed in other types of mills. North[8] related the physical properties of materials to their behaviour on grinding. Hardness governed to some extent the particle-size distribution of the product, but toughness was also very important. Other factors were, of course, the size of feed to the mill and the fineness of product required. The important characteristics of the product to be ground were also discussed by Quesnel,[9] who enumerated three fundamental methods of grinding: namely, crushing between fixed and moving parts, impact pulverisation and tumbling. Of the available grinding equipment reviewed, the tri-conical Hardinge ball mill was claimed to have the greatest efficiency. The principles and

action of various types of crushing and grinding machinery were tabulated by Waganoff[10] and the practical factors attaching to the designing of ore milling plants were discussed in a readable article by McNeill.[11]

Primary crushing

Gauldie[12, 13] made masterly contributions to the understanding of the operation of jaw crushers and gyratory crushers. In the first article, a mathematical and geometrical study was made of a jaw crusher used for the preparation of crushed stone aggregates. The relationship between the geometry of the jaws and the output was determined. Equations were developed based on certain assumptions, namely that the angle included between the jaws at nip level was low enough to ensure that the largest lumps fed to the hopper were caught and broken without recoil; that the outlet jaw surfaces were correctly contoured to discharge the crushed material; that the charge in the hopper did not exceed the practical maximum for the crusher and that free descent of the grist occurred immediately the moving jaw moved backwards. In his second paper, the author likens the gyratory crusher to the jaw crusher in which a large number of elementary V-shaped jaws operate in succession. 'As far as output is concerned, the moving crushing surface,' he states, 'may be regarded, therefore, as expanding and contracting, umbrella fashion, in simple harmonic manner.' Crushing with the gyratory occurs, therefore, during the 'expansion stroke' and descent of the crushings takes place during the 'contraction stroke.' The output of the gyratory crusher was subject to calculation in much the same way as with the jaw crusher. For a 36-in. gyratory crusher with a 56° cone base angle working on stone, the optimum speed for maximum output was about 400 r.p.m. The author calculated performance curves showing the increased output obtainable by opening the discharge settings, increasing the base angle and reducing the frictional characteristics of the material. The aim in operating the gyratory crusher should always be to prevent over-compacting of the material being crushed and, when this condition was just satisfied, the optimum output was obtained.

The distribution of the charge to the gyratory crusher is always a matter of prime importance in governing performance and there are three new British patents relating to improvements in this direction.[14, 15, 16]

[*Christy & Norris Ltd.*

The body of the disintegrator shown here is supplied not only in cast iron, but also in phosphor bronze and stainless steel. The beater-cross and screens can be made in similar metals to the body so that, where necessary, the material being ground comes into contact only with phosphor bronze or stainless steel. The disintegrators are usually used for dry grinding, but they are applicable also to wet grinding duties under specially controlled conditions. The disintegrator is supplied in two laboratory sizes and three commercial units. The one illustrated is an 18-in., 10-h.p. unit.

The primary crushing of iron ore for the Queen Victoria blast furnace at Appleby Frodingham, one of the largest in Europe, is accomplished by roll crusher.[17] Each roll is 6 ft. in diameter by 5-ft. wide and is driven at 180 r.p.m. by a 200-h.p. motor. The crusher rolls can be set to 6½-in. clearance and the crushed product is separated into two fractions, over and under 2-in. size. The oversize is passed to secondary crushers for further treatment. Primary crushing equipment for iron ore has featured also in two British patents.[18, 19]

Intermediate (secondary) crushing

Erickson,[20] working with Mesabi iron ore of intermediate grade, showed that the iron content of the product was raised slightly during the course of batch tests in a 6-in. cyclone. The author was not able to determine whether this process could compete with normal abrasion milling.

Roller mills have received the attention of inventors. Two British patents[21, 22] claimed methods of arranging the loose and fixed rollers parallel in the roller frames for ease of adjustment. Another arrangement for adjusting the rolls[23] and a method of cleaning the break rolls[24] were claimed. In the latter, the comb-like stripper was mounted on its support bar in such a manner that it could be clamped firmly and yet be adjustable. A hydraulic control mechanism for controlling the pressure on the rolls for a paste mill has been patented.[25]

D. R. Tullis[26] claimed an electronic sequence timer governing the feeding mechanism, and the operation of the defibring mechanism in a hammer mill. A vibrating device for grinding and breaking up granular materials[27] comprised a suitable vessel containing a loose ram or ball which narrows continuously towards the outlet situated in the bottom of the grinder. Another British patent[28] specified an improved pin mill. The *Contraplex* mill[29] is a type of pin mill in which the two pinned discs revolve at high speeds in opposite directions. Pin mills are particularly suitable for the grinding of free-flowing, crystalline solids, drugs, etc. One type of pin mill with many interesting features has been described[30] which is made in the range of sizes and capacities given in Table 1.

Fine grinding

Crusher bars running lengthwise in the ball mill were the novel feature of a new design by D. Weston.[31] The mill, charged with 5-in. balls to the extent of only 3% of its volume, worked on a material charge of 30%. It was claimed that the action of the crusher bars was to simulate the behaviour of a jaw crusher, the bar being regarded as the moving jaw, while the heavy ball acted as the stationary jaw. Advantages were claimed in respect of work done for a given power input, always provided the balls were kept to within the size range 5 to 3 in. only. In order to obtain the desired short-ball trajectory, the speed of the drum was 90% of the centrifuging speed.

Sticky materials can often be granulated more readily when chilled, but it has been claimed[32] that, with heat-sensitive minerals like quartz, the grinding efficiency might be favourably influenced by raising the temperature. In grinding paint, temperature also plays a part and a method of

Table I. Sizes and Capacities of a new Pin Mill[30]

Diameter of pinned discs (in.)	*Spindle speed (r.p.m.)*		*Motor size required*	*Approximate output (lb./hr.)*	*Size of raw materials up to (in. cube):*
	Maximum	*Minimum*			
12	4,200	3,500	5 to 10	100 to 600	½
20	2,750	2,250	15 to 20	300 to 1,500	1
30	1,850	1,600	20 to 30	650 to 3,000	1¼

water cooling a ball mill has been claimed.[33]

Following the appearance on the market of so-called 'high-density' grinding media, both spherical and cylindrical in shape, Davis[34] determined their action on the wet grinding of glaze frits as compared with standard flint pebbles. The denser balls appeared to be more effective in the breaking down of coarse frit, but the size of the balls became the more important factor in reducing the frit to a very small particle size. In the milling of enamels[35] the use of heavy-density grinding balls resulted in a saving of 45% in time of milling.

The output of a mill and the quality of the product depends in no small measure upon the equipment for feeding in the raw material. Taubmann[36] described an automatic feeding device for a tube mill which makes allowances for variations in hardness of the clinker feed. The tube mill was studied also by Jacob,[37] who suggested a 'composite efficiency number' as a measure of the efficiency of grinding. This number was obtained from a derived formula in which the terms were:

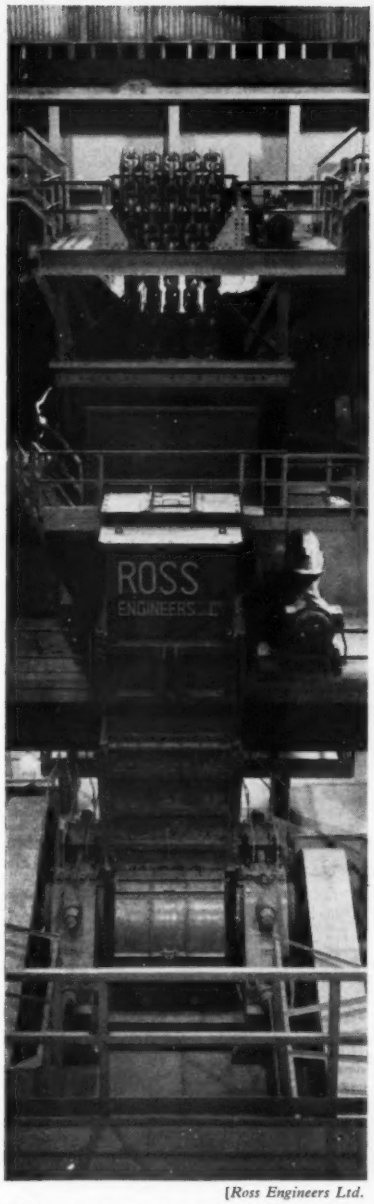
(*a*) Power consumption in kwh.
(*b*) Output in tons/hr.
(*c*) Specific output (kg./kwh.).
(*d*) Output per cubic metre of grinding space.
(*e*) Residue of ground material in B.S. No. 170 sieve.

Patents[38, 39, 40] claimed modifications in pulverising machines relating, respectively, to the fine grinding and sifting of the particles by a cyclonic process, control of air in swept mills and the grinding of fibrous materials.

Crushing and grinding in industry

Much of the literature on size reduction is relative to the applications of various crushing and grinding techniques as applied to industrial processes. The crushing and handling of Venezuelan iron ore was described by Millard.[41] Details were given of the installation at Puerto Ordaz, where 6,000 tons/hr. of ore are transferred from mine cars to storage and to seagoing ships. A process for the crushing of sylvinite ores has been claimed.[42]

Swing-hammer mills are traditionally applied universally for the disintegration of fibrous materials. A new 14-page illustrated brochure[43] described British-made swing-hammer shredders for the reduction of a large range of commodities including angelica root, bark, copra, cork, corn cob, fruit peel, ginger and liquorice root, paper, peat, town's refuse, straw, tobacco and wood refuse. These machines have been applied both as primary units and in multi-stage processes. Three patents[44, 45, 46] claimed improved apparatus for the milling of wood, asbestos and similar fibrous ore bodies.



[*Ross Engineers Ltd.*

This primary ore crusher, of capacity 1,000 tons/hr., was fitted at the plant of the Appleby-Frodingham Steel Co. The iron ore from this crusher is passed to secondary crushers which produce lump −2½ in. for the blast furnace and the fines −¾ in. pass to the sintering plant.

Crushed stone, which is in large demand today for facing concrete, makes special demands on crushing equipment. Goldbeck,[47] in a carefully written paper having 71 references, described the production methods and trends for commercial crushed stone. Utley[48] gave details of a 30 × 20 in., double, conical, rock crusher which was specially designed to reduce the amount of unwanted flat-type particles during stone crushing. The basic principle of the crusher is the use of two mated, corrugated shells, one convex and the other concave, so designed that the setting space between them remained constant. The rotating shells worked at a maximum speed of 140 r.p.m. No springs were employed; instead, the desired compression was obtained from two hydraulic cylinders containing oil and gas. The oil gave the positive pressure required and the gas present permitted of a certain amount of elasticity to prevent damage to the shells due to tramp iron. The machine described handled 2½-in. material at 100 tons/hr., crushing to a ⅜-in. product.

Gregg *et al.*[49] studied the effect of grinding on the kaolinite particle in china clay. The main effect was an increase in the specific surface of the kaolinite, with an increase in the base-exchange capacity. Grinding distorted but did not destroy the lattice structure. Ball-milling studies on pure alumina and magnesia[50] indicated that the strength value of formed pure oxide bodies was increased by milling the fused raw material in a non-aqueous medium such as alcohol. A superiority was claimed for the impact mill as a means of crushing clay for the brick and tile industry.[51]

For the pulverising of coal for combustion purposes, ring and ball mills are well established. All the grinding elements of one well-known make[52] of ring mill are so constructed to give long life and maximum accessibility. The plant was designed to work with a minimum of maintenance and a good feature claimed is that the wearing of working parts does not affect the fineness of the powdered coal. In a descriptive article, general details were given of the ball mill, ring-roll and tube mills for the crushing of coal. A new, horizontal, impact mill has been claimed[53] which serves the dual purpose of grinding airborne coal and blowing the pulverised fuel to the steam-boiler firing position.

The manufacture of nitro-chalk[54] presents an interesting limestone-crushing problem. The mills operate in a closed cycle, the crushed stone being pneumatically transported to the ammonium nitrate treatment plant. The process of crushing was made

largely automatic to interlock with the continuous operation of the rest of the plant.

Ball milling was described as becoming increasingly important in the preparation of modern vitreous enamel frits.[55] It has gradually replaced triple-roll machines, pan mills and edge runner mills. The rubber-lined and more recently the solid rubber-walled mill has superseded the steel mill, since iron contamination of the enamel frit must be avoided. The desirable size of the pebble grinding medium was $1\frac{1}{2}$ to $2\frac{1}{2}$ in.

Materials of construction

Martensitic cast iron is still a most favoured lining metal for ball mills, crushers and hammer mills. One type of hammer mill for the preparation of ground feeding stuffs used exclusively *Ni-hard* liners.[56] For the grinding of cement in tube-cum-ball mills,[57, 58] *Ni-hard* martensitic cast-iron balls gave lives $3\frac{1}{2}$ times and 4 times longer respectively than forged-steel balls. Experiences obtained with cement mills working in two localities in the United States are summarised in Table 2.

For mills where resistance to impact is more important than wear resistance, steel still holds its own. A British patent[59] claimed a silicon-chrome-manganese steel which had proved admirable for the lining of drum-type mills subject to shock.

Norris[60] wrote on the value of alternative shapes of mill grinding media by comparison with balls. The sphere, sphere with six flat faces, cube, circular cylinder, circular disc and a combination of cube and octahedron, all made in steel, were tested in a laboratory ball mill 9.9-in. diameter by 19.5-in. long rotating at 60 r.p.m. In terms of mill capacity, power consumption per unit of undersize produced and rate of wear of grinding media per unit weight of ore milled, the spherical shape proved much the best. The development of the high-density ceramic ball was reviewed by Redd.[61]

Austenitic manganese steel with wear hardening characteristics has long been used for the manufacture of jaw crushers and other heavy-duty breakers. Miles and Keith,[62] in an illustrated article, described crushing equipment for the clay industries based mainly on the austenitic manganese steel. One application where this steel shows up unfavourably was stated to be for ball-mill liners where the 'spreading' under impact abrasion distorts the lining and puts too great a strain on the fixing bolts. These authors gave the data reproduced in Table 3, which summarises the behaviour of several steels when used for jaw-crusher service.

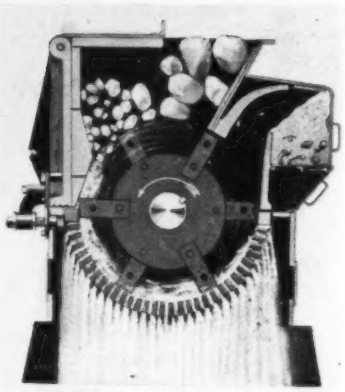
Manganese steel was also applied to the wearing parts in several types of clay-working machinery.[63] This same reference covers a short article on a steel planetary ball mill of 70- to 90-cc. capacity suitable for the laboratory grinding of clay.

Novel methods of comminution

A laboratory disintegrator of considerable interest was described recently.[64] This 'angle disintegrator' gives an even particle-size reduction with the separation of the product into primary and secondary fractions. It is claimed to be suitable for crushing, grinding, pulverising, pulping, shredding, triturating and defibrising. Similarly, this all-purpose laboratory tool can be equally well adapted for homogenising, blending, dispensing, beating, dissolving or mixing. A perforated steel screen completely surrounds the swept area of a steel rotor. The feed, introduced above the centre of the rotor, is thrown outwards towards the screen. This screen allows the primary and secondary products to be separately discharged. 'A miniature paint factory in a test tube' is the description applied to a laboratory, portable, test-tube mill.[65] Corked tubes placed in a rack are uniformly agitated until the complete dispersion or mixing of pigments is secured. A process and plant for converting molten materials into a granular or powdery crystalline product was claimed by J. E. Nyrop.[66]

Finally, Forsyth[67] and also Corcoran[68] wrote on methods of determining particle size—after all, a most important adjunct to the technology of size reduction.

(*References on page* 236)



[*British Jeffrey-Diamond Ltd.*

Sectional illustration of B.J.D. swing-hammer pulveriser. This unit is suitable for the crushing of a variety of chemicals and minerals to 100 mesh in one stage or 200 to 300 mesh in two stages. The breaker plate is adjustable for wear by means of an external adjusting screw. The double-ended hammers of the rotor crush against a stout breaker bar. These hammers can be used in four positions so as to utilise the four wearing corners.

Table 2. Experiences with Cement Mills in the U.S.A.

Mill No.	*Charge*	*Operating hours*	*Cement ground (bbl.)*	*Wear (lb. lost)*	*Ball consumption (lb./bbl.)*
	CALIFORNIA				
3	1-in. Steel balls	13,553	284,600	40,200	0.14
9	1-in. *Ni-hard* balls	14,170	297,500	12,450	0.041
	PENNSYLVANIA				
1	$\frac{7}{8}$-in. *Ni-hard* balls	7,485.06	284,058	4,000	0.0146
2	$\frac{7}{8}$-in. " "	7,610.05	288,801	3,000	0.0104
4	$\frac{7}{8}$-in. Forged-steel balls ...	7,784.02	295,405	15,000	0.0508

Table 3. Summary of Wear in Jaw Crusher Services

Material	*Wear of jaw surface* (g./sq.in./1,000 lb. of stone crushed)*	
	Fixed jaws	*Moving jaws*
Mn steel (1.21% C, 11.9% Mn)	0.072 to 0.191	0.086 to 0.124
C steel (0.24% C)	1.26	1.21
C steel (0.50% C)	0.95	1.07
Cr steel (0.26% C, 1.23% Cr)	0.19	0.82
Cr steel (0.59% C, 0.73% Cr)	0.72	0.82
Ni steel (0.24% C, 3.63% Ni)	0.58	0.47
Ni steel (0.55% C, 3.29% Ni)	0.43	0.48
Ni-Cr steel (0.44% C, 1.38% Ni, 0.44% Cr)	0.41	0.39
Ni steel (0.46% C, 6.24% Ni)	0.24	0.27

*From J. H. Hall, *Proc. A.S.T.M.*

AIR-POLLUTION CONTROL

WORLD PROGRESS REVEALED AT NEW YORK MEETINGS

By R. W. Moncrieff, B.SC., F.R.I.C.

The First International Congress on Air Pollution was held in New York recently, organised by the American Society of Mechanical Engineers to mark its 75th anniversary. Our contributor reviews critically those aspects of the Congress that are of most interest to readers of CHEMICAL & PROCESS ENGINEERING. *His report will appear in two parts—this first part covers engineering research and development; progress made in air-pollution control in Italy and the Netherlands; and methods of sulphur dioxide removal used in Britain and the United States.*

THE CONGRESS was truly international and, while naturally the greater number of speakers were American, there were also some from the United Kingdom, Canada, the Netherlands, France, Italy and Portugal.

A particularly noticeable feature was the considerable disparity in outlook between the laboratory workers, chemists, physicists and engineers who were attacking the problems of air pollution from the standpoint of basic research, and the plant managers and superintendents who had already had to mitigate as best they could the nuisance that their factories were causing. The research engineer was inclined to be caustically critical when he heard of large volumes of very hot gases going up stacks with inevitably large losses of sensible heat, but one production engineer assured me that a rise in temperature of only 1°F. in the stack effluent was equal to another 5 ft. on the height of the stack; new filtration techniques which seemed attractive to the laboratory worker were viewed more than doubtfully by plant managers. Which group has the more justification for its viewpoint only time will show.

Engineering research and development

The engineering research and development needed was discussed by **Dr. L. Silverman,** Associate Professor of Industrial Hygiene Engineering at the Harvard School of Public Health. He talked about 'sins of emission,' and drew attention to the need for further research in the following ten aspects of air pollution:

(1) New methods for treating fine metallurgical process fumes at high temperatures.
(2) Methods for controlling acid mists and organic suspensoids.
(3) New methods for recovering chemical effluents which are difficult to absorb or remove by contact washing.
(4) New devices for the combustion of low levels of gases which create odour problems and yet are too concentrated to adsorb on odour canisters but not concentrated enough for a major recovery system.
(5) Study of the dynamics of particles and especially their separation, filtration and electrostatic properties.
(6) Study of the photochemical stability and physical chemistry of aerosols.
(7) Studies on the life of filters for a variety of aerosols.
(8) Studies on graded filter media for low loadings of air contaminants.
(9) Development of fabrics able to perform efficiently at 500 to 1,000°F. (260 to 540°C.).
(10) Development of relationships between particle properties and equipment performance to enable prediction of a suitable method of treatment for a rapidly evaluated particulate material.

These lines of investigation cover a wide field and there can be no doubt that, if such investigations were made, our knowledge of ways in which air pollution can be prevented would be greatly extended.

Dr. Silverman discussed the economics of processes for absorbing or precipitating particulate matter. Occasionally, by-products that were recovered would partly offset the cost of purifying an effluent gas, *e.g.* in the recovery of sulphur in the form of sulphuric acid from smelter gases and in the recovery of noble metals from the same gases. More often, however, the waste gases contained nothing of appreciable value, *e.g.* those from the open-hearth furnace in the steel industry; these were non-toxic, but they could create a nuisance and could influence the visibility in the neighbourhood of their discharge. Some disservice to the control of air pollution had been done by high-pressure salesmanship of equipment that was not always suited to the material that had to be treated. Sometimes, bag filters were used to remove particulate material, but often these had only a disappointingly short life because of the corrosive gases also present. Education in both technical colleges and industry was necessary; the study of air pollution should form part of a student's curriculum.

Silverman described research that was currently being carried out at the air-cleaning laboratory at Harvard for the American Iron and Steel Institute; this concerned the purification of open-hearth gas effluent. A continuous filter of slag wool fibre had been built; the slag wool fibre costs less than 1½ cents per lb. and can be made with a mean diameter of 4μ, and will withstand a temperature of 800 to 1,000°F. Experiments have been made only on a small scale, but they have so far indicated that the filter will remove up to 95% of the iron oxide that is present in fine particulate form, mostly less than 0.1μ in diameter. How much of the sulphur dioxide the filter would also remove was still doubtful. The process would have a reasonable operating cost. In the subsequent discussion, doubt was expressed by representatives of industry as to the efficacy of such a filter under practical conditions, and particularly at the high temperatures at which gas effluent is sometimes dispersed. Nevertheless, the approach seems to be a likely one and even if, as is probable, the experimental unit has to be modified very considerably for plant use, the new knowledge that is coming from the work should be valuable to industry.

Air-pollution control in chemical and other works in Italy

What we know of industrial pollution suggests that it should be common to all countries conducting similar industrial operations, with three qualifications. The first is that, if the site of industry is well away from centres of human habitation and from farmland, the pollution, although still present, may not cause any serious trouble. The second is that, when the industry is located in an advanced and very populous industrial region, the technical ability of the management and executive officials may greatly diminish the quantity and toxicity of the gaseous effluent, through more effective control of the processes. The third qualification is that the amount of pollution that will ensue from industrial operations is partly dependent on the surrounding terrain; in a hilly or mountainous neighbourhood, gases and vapours disperse much more quickly than in a river valley where vapours are canalised and where there is a concentration process to offset or at least delay the results of a natural dispersal.

This last factor of geographic influence was emphasised by **Dr. G. Pancheri,** director of the Medical Division, Ente Nazionale per la Prevenzione degli Infortuni, Rome, Italy. The peninsular shape and mountainous nature of Italy were responsible for this country's freedom from acute episodes of pollution. The valley of the Po was exceptional and there there had been a number of complaints.

Dr. Pancheri devoted much of his discussion to industrial accidents, *e.g.* benzene poisoning in rubberising factories, carbon disulphide poisoning in viscose rayon factories, benzene and carbon tetrachloride poisoning in rubber factories, carbon monoxide poisoning in ceramics works, chromium poisoning in a plating factory, and so on. Such instances as these are not quite what we have in mind as falling within the contemporary meaning of the expression 'air pollution'; they are rather indicative of inadequate factory inspection and safety control.

More in line with the subject matter discussed by other speakers was Dr. Pancheri's statement that 'we have many cases of diffuse eczema, asthma, rhinitis and allergic conjunctivitis, brought about by causes often escaping the patient's and the doctor's attention and which are due to industrial atmospheric pollution.' He instanced the case of Merano, a beautiful locality with a good climate, chosen as a site for many sanatoria. There, in a small side valley, there was opened a factory for the production of synthetic ammonia. 'The patients insisted on stating that it was sufficient only to see the typical yellow-brownish haze of nitrous gases coming out of the smoke stacks to start feeling ill.' The technicians at the factory stated that it 'was so far away from the town, and the residual gases were so few, they could in no way have a deleterious effect on the inhabitants.' Furthermore, 'this matter amused the technicians, and contributed to creating in many of them the conviction that the complaints were not based on facts but had a speculative origin.' One's sympathy lies with the patients and it is reassuring to know that they maintained their complaints until adequate corrective means were installed at the factory.

It is only of understatement that we can accuse Dr. Pancheri when he states: 'We know that feeling of rest, of euphoria, of *joie de vivre*, of uplift, which the places (Naples, Venice and Palermo) we have mentioned and others are capable of giving us, and of exerting on invalids, is due in part to the blue sky, to the clear atmosphere, to the beauty of the landscape, no matter whether it be wild or cultivated, composed of strong or soft colours. A cement factory might, in certain instances, be enough to destroy all the enchantment.'

In some instances of air pollution that have occurred in Italy, appreciable quantities of arsenic and of fluorine have been detected in the contaminated air. People living near the source of contamination suffered from nausea, vomiting, pains of the bones, disturbance of the calcium metabolism and bruises due to ruptures of the peripheral capillaries. Silkworms were particularly susceptible to the pollution and died in great numbers. Other pollutants that have been identified coming from different sites have been hydrogen sulphide, sulphur dioxide, sulphuric acid, nitrous gases, silicon fluoride and phosphate dust.

The towns of Massa and Farrara in Italy are so located that the prevailing winds blow for most of the day from the Tyrhennian Sea over chemical factories to the towns, the population of which make very insistent complaints. The chemical plants concerned manufacture nitric acid, sulphuric acid, ethylene oxide, chlorine, hydrochloric acid, phosphates and calcium cyanamide; there are, as well, a cement mill and an oil distillery. Pollution from these factories seems to be considerable and varied and to include coal dust, calcium carbonate, marble and cement dust, nitrous and ammoniacal gases, sulphur dioxide, hydrochloric acid, carbon monoxide, etc. Not only humans and animals, but also the vegetation of the neighbourhood suffered.

Dr. Pancheri's concluding paragraph is well worth repeating: 'Modern civilisation is greatly indebted to industry for the amazing increase in material welfare it has provided in the course of a few decades. But it is necessary that this same industry adopt all essential safeguards to avoid undermining our health, the possible aggravation of our physical sufferings, the upsetting of our psychological life, and the elimination, in full or in part, of the enjoyment Nature offers us.'

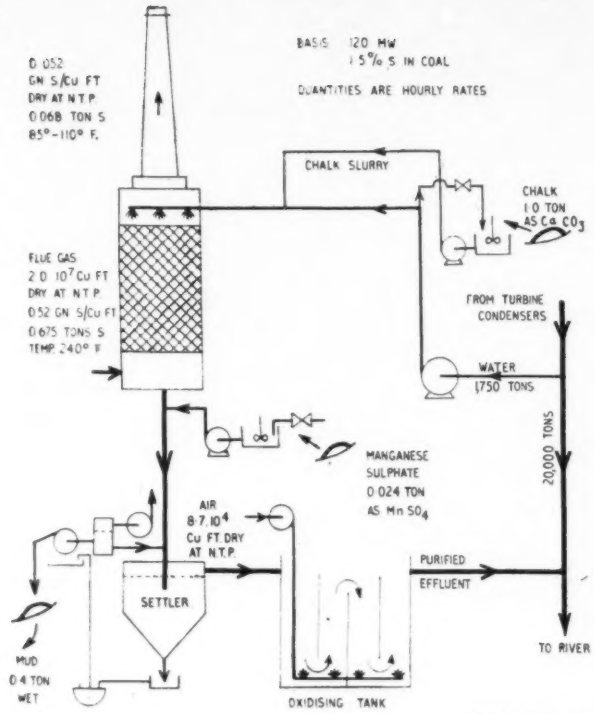
Progress in the Netherlands

Experience with air pollution in Holland was described by **Prof. A. J. Ter Linden,** of the Technische Hogeschool Laboratorium, Delft. A code of good practice has been established in that country, having been drawn up by a committee of specialists of different professions, *e.g.* hygienists, manufacturers of dust collectors, and works managers of dust-producing factories. The requirements of their code, which is applied to factories and to power stations, are:

(1) The dust content of the gases leaving the stacks must not exceed $\left(\frac{H}{50}\right)^2$ g. cu.m. (at N.T.P.), where H is the stack height in metres. If, for example, the stack is 50 m. high, then the dust content must not exceed 1 g./cu.m.; if it is 70 m. high it must not exceed 2 g./cu.m.; for 86 m. the limit is 3 g./cu.m. and, for 100 m. high, 4 g./cu.m. (Note.—1 g./cu.m. = 0.4 grain/cu.ft.)

(2) The content of coarse particles of diameter exceeding 50μ must not exceed $\frac{1}{40}\left(\frac{H}{50}\right)^2$ g./cu.m. This attention that is paid to minimising the concentration of large particles is probably of more importance in preventing heavy dust falls and damage to vegetation than in preventing or reducing pulmonary irritation. Fortunately the larger particles are easier to remove from the gases than the smaller ones.

(3) The height H of the stack shall be at least $1\frac{1}{2}$ times the height of



[*British Electricity Authority*

Flow diagram of the Battersea flue gas washing process, described to the Congress by Mr. R. L. Rees.

the highest building in the neighbourhood. In fact, it is stated, the code will only hold good for a flat country where high buildings are the exception. Furthermore, ' for large power stations and for installations surrounded by residential districts, more stringent rules will be advisable.'

As more evidence of the benefits that can result from voluntary action, ' the proposals were made in 1950. Although the rules were not required by law, people have responded well to them.' Clearly a systematic and enlightened approach to the problems of air pollution is well under way in Holland.

The Dutch committee which so successfully formulated the above rules has not yet issued regulations against air pollution by waste *gases*. The extreme sensitivity of the nose makes the question of odour removal more difficult than that of particulate waste removal. So far as concerns the immediate vicinity of a factory with a malodorous gas effluent, the provision of a high stack will obviously aid good dispersal and so minimise the olfactory offence in the neighbourhood. If, however, the odour is one that is very persistent and which can be detected from so far as 10 or 15 miles away, it is not likely that a high stack is going to improve the conditions at such a distance. Solutions of this problem were not discussed by Prof. Linden, but one of them at least consists of the injection of counteracting odorants through atomisers into the stacks. Devices such as this have been reported by von Bergen[1] to overcome the foul odours that can emanate from kraft paper mill stacks and which are attributable mainly to sulphides and mercaptans.

The importance of controlling air pollution was demonstrated by reference to two instances that had had most unfortunate effects:

(1) A large blast furnace and steel factory emitted an effluent containing SO_2 and sulphuric acid. Even small concentrations were found to do considerable damage to the cultivation of bulbs such as gladioli, which is an important industry in Holland.

(2) An oil refinery near Rotterdam emitted an odorous gas effluent which in certain wind conditions could be smelt even at Delft and at The Hague, some 10 to 15 miles distant.

Sulphur dioxide removal in the United Kingdom

Of all the contaminants which can affect air, sulphur dioxide is the one that has attracted most attention, and a large part of the practical work that has been done on minimising air pollution has been concerned with the removal of SO_2. The irritating smell of this gas and its liability to photochemical oxidation to sulphuric acid are responsible for much of this attention; the toxicity of the gas in the concentrations that are normally present in the air of an industrial city are not established necessarily to be toxic, but the likelihood is that, together with particulate carbon (smoke) which can adsorb and so concentrate on itself sulphur dioxide, harm may result to the lungs when the air contains both sulphur dioxide and smoke. Damage to vegetation has, of course, been observed when the concentration of sulphur dioxide in the air is abnormally high, and the corrosive action of the sulphuric acid that can be formed from the SO_2 and that can accumulate on neighbouring buildings is beyond doubt.

Mr. R. L. Rees, chief chemist of the British Electricity Authority, described to the Congress the removal of sulphur dioxide from power-plant stack gases. It may be noted that the U.K. Committee on Air Pollution included in their final report (1954) a recommendation in favour of removing sulphur from flue gases at new power stations in or near populated areas.

The Battersea process. This process, which is in use at the Battersea and Bankside power stations in England, is carried out on the following lines. The gas effluent is dedusted electrostatically and is then washed on grid scrubbers with water from the River Thames which already contains nearly sufficient alkali to neutralise the sulphur dioxide; a little chalk is added to the water in order to maintain the alkalinity in the later stages of the washing process; the effluent is aerated, a little manganese sulphate being added to oxidise the sulphite present in it to sulphate; the effluent is passed through a settler to remove the small quantity of solids and is then mixed with about 12 times its bulk of the water which is returning to the Thames from the turbine condensers. The process removes more than 90% of the sulphur dioxide in the effluent and one would think that the removal of some tons of sulphur dioxide hourly from the gases leaving a power station would be bound to improve the state of the atmosphere

substantially. So it does if the effluent gas is discharged from stacks that are short so that it is caught in the down-eddies that form in the lee of buildings as happened at older plants. The new power plants in Britain, however, have stacks that are at least 300-ft. high and that are at least 2½ times the height of adjacent buildings. If the gas is *not* freed from sulphur dioxide, it is discharged hot and at high velocity from these tall stacks, and it gets well dispersed into the atmosphere before it reaches ground level.

If, however, the gas is first washed to remove the SO_2, it is very greatly cooled and becomes saturated with moisture, so that it ' falls to the ground from time to time quite near the power station, although discharged from tall stacks.' In practice, according to Mr. Rees, the London public complain about the emissions from Battersea and Bankside power stations, from which most of the sulphur dioxide has been removed, but make no complaints about the other power plants with tall stacks where gas washing is not in use. Surveys in the neighbourhood of non-washing power plants have failed to show any change in sulphation rates; similarly, surveys in south-west London have failed to show any relation between sulphation rates and the amount of gas washing in progress at Battersea. Consequently the question is asked, are tall stacks enough?

There are two serious disadvantages to the Battersea process:

(1) It is costly. ' The present-day cost of the process at a new power station would be from 8 to 10 shillings per ton of coal burned; *i.e.* about 12 to 15% of the cost of coal delivered.'

(2) It cools the effluent gas so that it comes to ground much nearer the stack and so that it has no chance of escaping through the ceiling of an atmospheric inversion.

A third consideration which might well prevent the process being used on other power stations is that the disposal of the effluent—a dilute solution of calcium sulphate—requires the proximity either of the sea or of a large river which is already so heavily polluted that a little more contaminant will not matter.

The cyclic lime process. In this process the flue gases are washed with a continuously circulating liquor which is kept alkaline by the addition of either chalk or lime; the calcium sulphite formed becomes partly oxidised to calcium sulphate and precautions have to be taken to prevent the sulphate depositing on and so choking the scrubber. There is not an enormous quantity of liquid effluent, so that there is no restriction on the location of the plant where it is used; chalk and lime are cheap, but have to be provided to neutralise the *whole* of the sulphur dioxide absorbed and the product has to be carried away, which is costly and not easy, from very large plants. It is estimated that the cost of running this process would be about 17 shillings per ton of coal burned—more than one quarter of the cost of the coal. The process was, in fact, run for some years at Fulham power station, but was very troublesome to operate, although it effectively removed nearly all of the sulphur dioxide.

Ammoniacal liquor process. This was developed jointly by the Fulham power station staff and Simon-Carves. Essentially, flue gas is washed with ammoniacal liquor from gas-works or coke-oven plant, with the production of ammonium sulphate (and a little sulphur); this process has the advantage over the others discussed that the end product from the absorption of the sulphur dioxide can be sold and does not have to be washed out to sea or dumped; furthermore, the demand for ammonium sulphate as a fertiliser is so great that the market would not be seriously upset by its production from power-station gas effluent. As some of Britain's sulphuric acid is still produced from imported sulphur, the recovery of sulphur from flue gases would constitute an improvement in the national export/import ratio. The process is expected to be cheaper than those others described, but it seems, according to Rees, ' too optimistic to hope that it will make a profit'; it is restricted in its application by the availability of gas liquor, of which there is only enough to treat about six power stations in Great Britain.

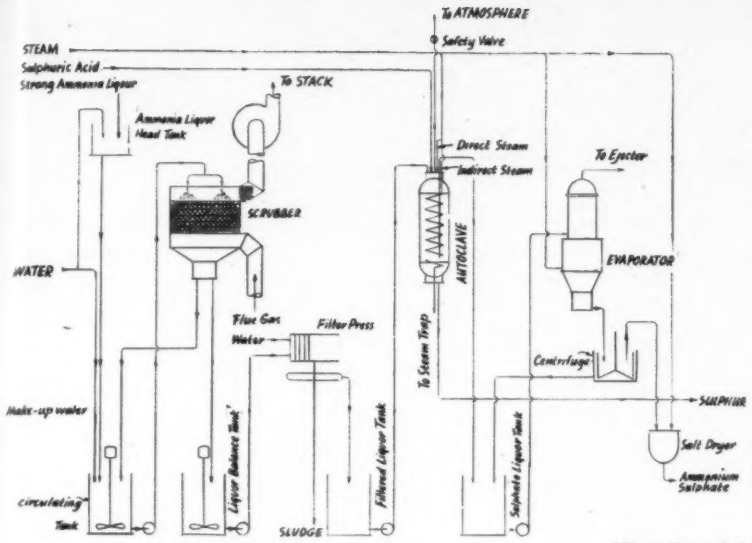
The ammonia process was later described to the Congress in more detail by **Dr. H. E. Newall,** of the D.S.I.R. Fuel Research Station. According to his description, the flue gases are scrubbed with a concentrated solution of ammonium sulphate, sulphite, bisulphite and thiosulphate; concentrated gas-works ammoniacal liquor is added at such a rate that it can absorb the sulphur dioxide. A small amount of sulphuric acid is added to the scrubber liquor and it is then heated in an autoclave at 180°C. and 200 p.s.i.; this decomposes the sulphite, bisulphite and thiosulphate to give sulphur and ammonium sulphate. An important practical point is that a vapour-pressure recorder can be used to regulate the addition of ammoniacal liquor in such a way that there is no excess of either ammonia or sulphur dioxide. The retention of balance keeps down the cost and keeps up the recovery factor of the process.

The efficiency of the original pilot-plant model was such that it removed about 80% of the SO_2 in the flue gas. A later development has been a two-stage scrubbing process, using a dilute solution of ammonium salts in the second stage, and this has increased the efficiency to 95%.

Cominco scrubbing system

The requirements at power stations and at chemical factories to avoid polluting the atmosphere by the liberation of SO_2 are rather different. Thus, at a power station, according to Rees, the gas flow is about 1 million cu.ft./min. containing about 0.1% SO_2, of which at least 90% must be removed. The different state of affairs that exists at a sulphuric acid factory was described by **C. Lawler,** of the Olin Mathieson Chemical Corp., Arkansas. The tail or exit gases from the sulphuric acid plant contained 0.9% SO_2 and more for short periods, a very much higher concentration than obtains at power stations, and it was required to reduce this to well below the figure of 0.1% which it was anticipated might become a legal requirement; in fact, a two-stage Cominco sulphur dioxide recovery system reduced the SO_2 concentration to 0.03% which, it was felt, would be ' more than satisfactory to any community.'

The Cominco (Consolidated Mining & Smelting Co. of Canada Ltd.) system uses a redwood scrubbing tower built so that the upper section is separated from the lower section, so that it is, in effect, a two-stage unit. Absorbing solution which contains ammonia is circulated in the top section to remove all but traces of the sulphur dioxide, anhydrous ammonia being used as a replenishment. Liquor is continuously bled from the scrubber to a stripper to which sulphuric acid is added to convert the ammonium-sulphite-bisulphite to ammonium sulphate, which is sent to a fertiliser factory, and to promote the evolution of sulphur dioxide gas which is returned to the acid plant drying tower for conversion to sulphuric acid. As much as possible of the sulphur dioxide is recovered as such, owing to the fact that it can be re-used, and as little as possible (consistent with good recovery) is converted to ammonium sulphate. This state of balance is



[Simon-Carves Ltd.

Simplified flow diagram, Fulham-Simon-Carves flue gas washing process.

achieved by using a minimum quantity of ammonia.

The process is working satisfactorily and is now being studied for application in the removal of sulphur dioxide from power-plant stack gases. ' Results developed to date look very promising.' ' Fundamentally, the Cominco sulphur dioxide recovery process finds application as a method for eliminating a pollution problem; however, in most cases, the economics are such that a long-term payout on the investment will be realised.'

Removal of sulphur from fuel to avoid air pollution

All of the sulphur dioxide and other sulphur compounds which are evolved at power stations come from the fuel. Similarly, in the manufacture of iron and steel, it is the fuel which is the source of the sulphur dioxide evolved.

According to **Dr. T. P. Colclough,** technical adviser to the British Iron and Steel Federation, who described to the Congress the role of sulphur in iron and steel making, the sulphur content of the coal used in this industry is about 1.2%, and some 60% of the sulphur in coal is retained in coke. As the fuel contains so much sulphur, much of which either at power stations or at steel factories is converted to SO_2, it is reasonable to enquire if anything can be done to eliminate the sulphur from the fuel, or at least to reduce considerably its concentration.

As was described to the Congress by Rees, the British Electricity Authority has investigated the possibility of removing the much-denser pyrites from coal. The particles of pyrites are so very small that there could be hope of effecting this separation (*i.e.* by mechanical means) only when the coal was pulverised. It has been shown by Whelan[2] that pyrites in the form of marcasite is often disseminated in the coal very finely as discrete grains varying in size from 0.5 to 40μ, or as small concretions varying from 20 to 100μ which also contain coal substances. Because particles of pulverised coal lie mostly within the range 20 to 50μ, mechanical separation would be difficult, but the possibility is being followed up.

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[1]J. M. von Bergen, paper presented 40th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, February 1955.

[2]P. F. Whelan, *J. Inst. F.*, 1954, **27**, 455.

The fate of sulphur in iron and steel making, the prevention of hydrogen sulphide pollution, the effect of recovery on world supply of sulphur, aerosol particle-size measurement and the design of equipment used in air-pollution control are among subjects to be covered in a continuation of the foregoing report with, finally, some general impressions from the Congress.

Corrosion Problems in Laying Fertiliser Works Foundations

It is really surprising how often heavy contamination of the soil with acids and soluble sulphates is discovered on sites within existing fertiliser works. This sometimes results from cracked drains, but more often has been caused by indiscriminate use of the ground as a dump for pyrites cinders, chamber sludge, clinker or as a soakway for process liquors.

This was pointed out in a paper presented to the Fertiliser Society recently by C. W. Marler, at the beginning of which he referred briefly to site investigations prior to laying foundations for a fertiliser works structure.

Heavy contamination of the soil with sulphates or acids could be a big problem. There have been a number of sites where acid concentrations of up to 3% and sulphate concentrations of 8 to 9% (on a dry basis) have been found at a depth of 4 ft.

Even at 8 ft. depth 0.5% of soluble sulphate has been found. Admittedly some of these sites were formerly occupied by sulphuric acid and sulphate of ammonia plants, but the figures give some idea of what can be expected and illustrate the care that is necessary with the installation and maintenance of floors and drains in such locations.

The use of areas near existing buildings or those which are earmarked for development for dumping wastes can lead to untold trouble. The only really satisfactory method of improving the site is to remove the contaminated soil and back fill at a cost of something like 20s. to 30s. per cu. yd. Where new work is contemplated this expense can be weighed against that of using dearer construction materials, but when old buildings are affected there is no choice, and to the costs of reclamation and repair must be added those which arise from the structure being out of service. For new work trouble of this sort could add 10 to 15% to the cost of foundations.

Outside the coking and gas industries it does not seem to be generally recognised that the drainage from heaps of coke, clinker and coal can be acid and contain sulphates. The concentrations are not usually high but are sufficient to cause corrosion of ferrous materials and degradation of ordinary concrete over a period of years.

The Widening Field of CHEMICAL ENGINEERING

Sir Harold Hartley on Some Borderline Developments

Extractive metallurgy

WE are living more than ever in a machine age. Everything is being mechanised to save human labour and effort and speed up productivity. With that goes an increasing demand for metals, and in spite of alternatives like plastics and bonded materials and the use of scrap the demands for virgin metal are rising. There is also the increasing use of new metals like titanium, zirconium and beryllium. At the same time many of the richer ore deposits are being depleted and we are dependent more and more on lower grade ores often containing a mixture of minerals which are very finely disseminated. For the treatment of these the older physical methods of ore-dressing, producing concentrates for smelting, are proving inadequate, and they are now being supplemented by various chemical engineering techniques.

There are two main developments; first the recent extensions of the old method of leaching the ores or the tailings from previous extractions with solutions, sometimes under pressure, to dissolve out the metal contents, and secondly the treatment of the ores in a fluidised bed. The advantage of the leaching process is that it can be used for very low-grade ores and allows the separation of different metals by a variety of different methods: precipitation, electrolysis, solvent extraction or extraction by ion exchange resins.

Thus uranium is recovered from the tailings on the Rand by leaching with sulphuric acid and ion exchange. Manganese can be recovered from low-grade ores or open-hearth slags by leaching with sulphur dioxide, or by preliminary roasting in a reducing atmosphere followed by leaching with ammonia and carbon dioxide or with nitric acid. Nickel sulphide concentrates are being leached with aqueous ammonia and oxygen under pressure giving ferric hydroxide and a solution of the ammines of nickel, cobalt and copper from which they can be separated. A large ore deposit containing less than 1% of copper oxide is being leached with sulphuric acid.

The fluidised-bed method of treating ores under controlled temperature conditions with various gases also offers a number of possibilities. Iron oxide can be reduced to magnetite for magnetic extraction and commercial plants already exist for using this technique for roasting pyrites. Copper nickel and cobalt ores can be converted to sulphates or chlorides by treatment with sulphur dioxide or chlorine in a fluidised bed, followed by leaching with water. Manganese in low-grade ores can also be converted to sulphate in the same way.

Another important aspect of the chemical approach to problems arising in ore treatment is the extraction of metals from the slimes that are often unavoidable and may carry sufficient of the metals to prevent the economic exploitation of a low grade deposit. Selective flocculants are giving promising results and the polyvalent ions are being used as flocculants in the recovery of uranium from large quantities of slimes from the treatment of Florida phosphates.

Another process under development is the extraction of gold from cyanide solutions by active carbon which would effect a considerable economy in cyanide and might avoid a considerable capital expenditure on thickeners and filters. Molybdenum can be separated by a similar method.

Hitherto most of the development work in this new field has been done in the United States and Canada where the exploitation of mineral wealth is a major part of the economy. But it is essential that Britain with her large mining interests should keep abreast of progress. This seems to me to involve a new approach to technological education in the field of mining and extractive metallurgy. In the United States at Columbia and M.I.T. mining engineering is kept separate from mineral engineering which includes all processes of ore treatment and extractive metallurgy, in which chemical engineering techniques are now so intimately involved. Some such innovation is needed here and it is suggested that some universities should establish departments of mineral processing and extractive metallurgy working in close touch with departments of chemical engineering.

This new field is so wide and of such commercial importance that there is a strong case for the establishment of a national institute responsible for research and development in mechanical ore treatment and extractive metallurgy similar to the Bureau of Mines of the U.S.A. and the Department of Mines and Technical Surveys in Canada.

Biochemical engineering

Three years ago I drew your attention to the growing importance of applied microbiology or biochemical engineering, as I prefer to call it. I compared the limitations of the man-made catalyst with the ability of the enzyme systems to build the most complex proteins and polysaccharide molecules by their template methods with a cleanness and efficiency that we can never hope to emulate without their aid. Since then rapid progress has been made and the growing industrial importance of this field has been recognised in the United States, for instance by the new Institute for Research in Microbiology at Rutgers University.

Meanwhile I have been criticised for suggesting that there is anything new in biochemical engineering, which my critics say is just the application of living catalysts in place of, let us say, platinum and that it needs no new techniques. My reasons for differing from this view are quite simple. During the lifetime of an inorganic catalyst it will continue to exert the same influence on any given chemical system with declining activity, as it is gradually poisoned or rendered inert. The living cell is entirely different as it often passes through various metabolic changes in its lifetime when its growth phenomena and its excreta undergo radical alterations on which its industrial application must be based. There are, too, such phenomena as the rapid alternation of light and dark reactions in the metabolism of photosynthetic organisms like chlorella of which its industrial use must take account.

In addition, there are the exciting prospects of the genetics of the living organism, hybridisation by sexual reproduction, the alterations induced by

'We are face to face with the problems involved in meeting the growing demands for higher standards of living for the ever increasing population of the world. On satisfying these demands may well depend the future of civilisation as we understand it in Britain. One fact is abundantly clear—that chemical engineering is intimately involved in supplying all those major needs, whether they are food, fuels and energy, water, metals, materials and drugs such as antibiotics. The techniques of chemical engineering are being applied every day in new fields'.

The foregoing comments were made by Sir Harold Hartley, K.C.V.O., F.R.S., *during his presidential address for* 1955 *to the Institution of Chemical Engineers. He outlined a few developments which seemed to him of special significance for the future of chemical engineering; these were in the borderline activities of extractive metallurgy, 'biochemical engineering' and in instrumentation and automatic control. Here we reproduce Sir Harold's remarks concerning these subjects.*

radiation and change of environment, and the possibility of training the cell to do its job more efficiently, as shown by the work of Sir Cyril Hinshelwood.

In industrial fermentations based on asexual fungi, strain improvement has hitherto been based on selection either among large collections of strains from nature or from spontaneous or induced variation in one strain. Professor Pontecorvo's discovery of what he calls the parasexual mechanism opens up a new possibility of breeding improved industrial strains of asexual organisms. He has found that in micro-organisms like Penicillium and Aspergillus niger there are natural processes (parasexual) different from sexual reproduction but leading to the same biological result. These processes differ from species to species, but the results are the same. They yield strains associating in new ways properties which were found separately in different strains before.

There is, too, the problem of maintaining a reliable strain of the organism. This does not necessarily mean maintaining an absolute genetical uniformity, which may not ever be possible. Rather it implies a population containing genetical variation but constant in a statistical sense. This may be achieved (as with Penicillium) by keeping a small elite strain, and building up anew from it for each fermentation; the population, and with it its variation, being discarded at the end. It may, however, also be aimed at by maintenance of a genetical equilibrium in the population itself through adjustment of the medium. Such an equilibrium would be required for a constant flow process, and the geneticist's problem (which he has yet to solve in general) is how to manipulate the population so as to achieve it.

So I am quite unrepentant in claiming a special place for biochemical engineering as a post-graduate subject in which a background of the characteristics of the living cell and enzyme systems would be added to a training in the techniques of chemical engineering. The value of such a dual experience is proved by the rapid progress it made possible in the production of antibiotics, one of the most significant advances in modern technology, both in its methods and results. A quarter of the output of antibiotics in America is now going into animal foods to aid both growth and resistance to disease.

Let me illustrate my point about the difference between the inorganic catalyst and the living cell by a few examples. As Hinshelwood has put it, 'a growing cell constitutes a manufactory with numerous departments, the conveyor belt leading from one to another being represented simply by the concentration gradients. Raw materials are broken down and built up into fresh forms in a series of stages.' As a general rule we do not know what is going on inside the immensely complex system of enzymes and co-enzymes, apart from the general inferences we can draw from empirical observations.

In the fermentation of sugars to alcohol, in spite of the complexity of the system, the close relation of the alcohol formed to the sugar utilised shows the kinetic interdependence of these two processes. But this is an exceptionally simple case. Usually the relations between growth oxidative metabolism and product formation are far more complex. In the production of citric acid from sugar by Aspergillus niger there is first a growth phase, when the sugar is used primarily for tissue synthesis with little acid production, followed by an acid production phase, with a short intermediate period of growth, after which the sugar is again mainly converted to citric acid.

In the biosynthesis of penicillin, where the free energy is supplied by the oxidation of sugar, after an initial growth period the penicillin synthesis is highest when the carbohydrate utilisation and oxygen uptake have all decreased, indicating that the penicillin is formed by some secondary process and the free energy required is furnished in part by processes other than the oxidation of the sugar.

In the biosynthesis of proteins by algae like Chlorella, in the early stages of growth the main product is protein, while in the later stages fats predominate.

These examples give some idea of the varying nature of these fermentation processes and the close study which is required to decide on their most economical use in industrial production. This involves the investigation of the optimum environment for the fermentation, including nutrient concentrations, temperature, agitation and supply of oxygen, and, on the microbiological side, the study of the tendency of any particular strain to mutate and the search for the most efficient and constant strains of organisms. The influences of all these factors on the design of plant were discussed at a meeting last year of the Chemical Engineering Group of the Society of Chemical Industry in a paper by Warner, Cook and Train, in which they stressed the need for specialist studies in the field at post-graduate level.

In his Leeuwenhoek Lecture, Professor Kluyver contrasted the nutritional requirements of the animal kingdom, demanding a balanced mixture of carbohydrates, fats, proteins and several accessory food factors with the ability of unicellular organisms in some cases to satisfy their need of organic material by one single organic compound. Moreover, for the same bacterial species the nature of this organic food component can often be varied in an almost incredible way. For example, *Pseudomonas fluorescens*

can be grown in media which may contain one out of 80 different compounds, as varied as nonylic acid, bromsuccinic acid, isobutylamme or benzoic acid, showing its amazing enzymatic adaptability.

Professor Kluyver commented also on the great diversity of respiration substrates in the microbial world as compared with higher animals, and on the number of anaerobic catabolic processes by which bacteria can derive energy by the reduction of inorganic compounds of oxygen. An interesting example of this, which should be turned to practical account, is being studied at the Chemical Research Laboratory at Teddington. A strain of bacteria *Desulphurvibrio desulphuricans*, if fed with inorganic sulphate, hydrogen and nutrient yeasts produces hydrogen sulphide which can then be converted into elemental sulphur. A large amount of sulphur could be produced annually in sewage farms by these bacteria. With the enormous potentialities in the use of micro-organisms and the increasing applications of single enzyme systems in industrial processes, biochemical engineering is bound to be of increasing importance in the future.

Instrumentation and automatic control

With full employment, one of the limiting factors to increasing the volume of production in Britain is manpower, but a greater use of instrumentation and automatic control offers both the advantages of higher productivity and improved quality, a combination not always found in some of the other ways of increasing output per manhour.

In the chemical and process industries the whole tendency is towards continuous plants with the economies they offer in capital cost, manpower and throughput—whenever the volume of production is sufficiently great. Such continuous plants have demanded a large amount of instrumentation and automatic control, and one of the main purposes of a pilot plant is to investigate the instrumentation required. In many cases the plants have been designed and the instruments and control added later, and, in fact, all processes are really manually controlled, because every major load change in general requires re-setting to the desired values of all the controls. Electronic devices are much quicker and more accurate than the human senses, and with appropriate servo-mechanisms they offer great advantages. With the rapid advances in the design of automatic controls, design engineers have been able to make considerable improvements by the incorporation of the latest standard instruments as they come on the market. Recently this approach to the process design problem, the addition of controls to process flow sheets, has reached something of a stalemate. It is now clear that the major advances will only be achieved if the use of automatic control is considered in the earliest design stages. This means that there must be consultation between the chemical engineer and the automatic control engineer from the earliest stages, and a sympathetic understanding between them.

We must move on from the stage of adding process controls in an empirical manner. This is not an easy matter, however, and it will call for a basically new approach to the problem of process design. Two difficulties appear to stand out. First there is a grave shortage of automatic control engineers with the necessary experience. Coupled with this is the shortage of chemical engineers with sufficient understanding of the theoretical approach to automatic control. Secondly, there is an almost complete lack of the information on plant and process characteristics which is required to enable automatic controls to be applied in a scientific way. Thus we have to face a dual problem of education and training on the one side, and lack of quantitative data on the other.

It is easy to illustrate the latter point by comparison with the method of design and automatic controls for mechanisms like gyrostats or rolling mills, in which the dynamical characteristics of the various elements are known, for example their inertia, so that theory can be applied to control design, and the results tested in an electronic simulator in which the effect of variations in the mechanism or the control equipment can be seen in an oscilloscope, thus making it possible to design the best types of control for the purpose in question.

This is rarely possible at present with a process at the flow-sheet stage of design, because the essential data concerning the effects of disturbances on the operation of the units of the process are unknown. The research chemist hitherto has only been interested in investigating a steady state. A twofold approach is necessary. On the one hand the characteristics of the plant, its reactions to disturbances, can be investigated on the laboratory and semi-technical scale and compared with theoretical predictions, thus building up a body of tested knowledge and technique with which to predict the characteristics of a full-scale plant. On the other hand, it is essential that every opportunity should be taken of determining the reactions of plants to disturbances in their working conditions, so that we can accumulate a body of knowledge of their dynamic characteristics, which can then be correlated with the predictions of their behaviour based on theory checked by laboratory and semi-scale investigations. Only in this way will it be possible gradually to accumulate data and experience of plant characteristics, in order to apply theory with confidence to determine the design and method of operation to give the most economical results by means of quality control. The urgent need to collect data concerning the operating characteristics of full-scale plants and, particularly, to carry out the basic theoretical work, is another strong argument for the co-operative research institute of which I have already spoken. In this connection, it is most encouraging to see that Imperial Chemical Industries is now extending very considerably its Central Instrument Laboratory, in order to accelerate the work directed to the improvement of control system design which it commenced immediately after the war. With the wide range of plant they are in such an advantageous position to contribute to the advancement of knowledge in this field.

The research chemist must learn to think in terms of the dynamic behaviour of processes and their relevance to control theory, and the chemical engineer must learn to co-operate with the control engineer, and provide him with the necessary plant characteristics for the design of control equipment.

This obviously implies closer working in future between the chemical engineering and the control engineering and electronic departments of universities, leading up to post-graduate courses in process control for those who propose to become specialists in that field.

Conclusion

These three fields of development, upon which I have just touched, present problems for the universities and colleges of technology if they are to progress and if Britain is to keep its place in the forefront of industrial progress. In the undergraduate course

(*Concluded on page* 214)

Some Chemical Engineering Problems of the IRON AND STEEL Industry

By A. H. Leckie, PH.D., F.R.I.C., A.M.I.CHEM.E.

Chemical engineering principles can play a big part in raising iron and steel productivity still further. The improvement of the manufacturing and refining processes, as well as the introduction of new ones, involves a number af unique problems which call for the chemical engineer's special knowledge. The author touches on many of these problems in this article and points to some of the changes that may be brought about.

THE Iron and Steel Board's recently published review* of the development of the steel industry between 1953 and 1958 was largely devoted to an analysis of the probable demand for steel over this period, and the way in which this demand could be met. Naturally this report did not deal in great detail with the technical aspects of the iron and steel making processes, and it may be of interest to examine what changes are likely to take place, not only between now and 1958, but also beyond that year, in the fields which most concern the chemical engineer.

One of the remarkable features of the British iron and steel industry is that its excellent performance in increasing productivity almost continually over a long period of years has been attained without any major change in the fundamental methods of manufacture since the Bessemer and Siemens Martin processes were invented about a hundred years ago, apart from the introduction of electric melting at the beginning of the present century. The improvements have been attained by increasing the efficiency of established processes (*e.g.* by the addition of ore preparation plant to the conventional blast furnace, by the introduction of continuous mills and by increasing the size of furnace units) rather than by radical changes in the processes themselves. A general account of the main manufacturing processes up to the ingot stage has been given in a previous article.[1]

The predominance of traditional processes for steelmaking for so long a period has not been due to any lack of initiative in finding better alternatives. The technical problems associated with handling large tonnages of chemical reagents in the form of molten metal and slag at steelmaking temperatures are formidable. The existing processes meet these difficulties effectively and economically, and most of the alternatives suggested to date, however attractive theoretically, have almost invariably failed either on straight economic grounds, or because they cannot produce good steel in the tonnages required to compete economically with the established methods.

However, in the last year or two the availability of large quantities of oxygen at a somewhat lower price has provided the opportunity of developing methods of steel refining which are sufficiently different from conventional practice to merit description as new, and yet appear to compete economically with traditional processes. Perhaps the best known of these is the L-D or Linz-Dusenverfahren process developed in Austria, to which reference is made later. Continuous casting plants have also gone into experimental production in Britain and elsewhere, and these represent a marked advance in the way of new techniques.

The question of interest to the steelmaker—and *ipso facto* to the chemical engineer, is: how will the future problems affecting the industry, which are touched on in the Iron and Steel Board's report, accelerate changes in existing processes and also the bringing in of new methods.

Many of the chemical problems arise from the tendency (which is by no means confined to the steel industry) for the raw materials to become less and less pure while the demand is for ever more stringent chemical specifications for the product. Thus the total amount of refining to be done is increasing. The normal materials flow at present is, of course, from ore through the blast furnace to make pig iron, then through the steel furnace to make steel. The extra refining which is becoming necessary may well bring a need for an additional partial refining process between the blast furnace and the steel furnace; such processes are already used at some plants.

Iron making and the blast furnace process

The first point to be noted from the previously mentioned report is that 1958 should see an increase in the output of pig iron of $3\frac{1}{4}$ million tons. This is estimated to require an increase of $1\frac{3}{4}$ million tons in the output of home iron ore from the quarries and mines in the United Kingdom and the importation of $4\frac{1}{2}$ million tons more ore from abroad. About 3 million tons more coke will be needed as fuel for the blast furnaces.

The present coke consumption in blast furnaces averages over 1 ton/ton of iron; the fact that in 1958 an additional $3\frac{1}{4}$ million tons of iron will be produced using only 3 million tons more coke is a measure of the expected increase in blast furnace efficiency, not of course in the new plants only, but also due to continuing improvements in the operation of existing blast furnaces.

One of the most important reasons for the continued improvement in the coke consumption of blast furnaces is the increased attention being paid to ore preparation and sintering. To a chemical engineer, it is almost self-evident that the blast furnace process, which is essentially a reaction between a hot gas stream moving upwards through a bed of broken solid, demands a prepared and sized bed for maximum efficiency. Yet it is only recently that ore crushing, screening and sintering have been carried out on a greatly increased scale, not because operators did not appreciate the importance of this before but because the economics of ore preparation, involving the production of large amounts of fines

*'Development of the Iron and Steel Industry, 1953 to 1958,' H.M.S.O., 1s. 9d.

which have to be sintered to preserve the size uniformity in the burden, only recently became clearly established.

Fig. 1 shows the growth in the proportion of sinter which is expected to be used in blast furnaces in the next few years. There has been a great increase in the amount of research done on the sintering process.[2, 3, 4] Although the process is intrinsically very simple, being the ignition of a bed of fine ore containing about 5 to 10% of coke breeze as fuel, with perhaps a small amount of slagging material admixed, control is important. The temperature and composition of the mix must be such that the particles adhere without true fusion, because a fused lump is not permeable to the reducing gases. Even distribution of the induced air blast among the sinter pans is also important. Thus, not only will the sintering capacity of the industry show the increase indicated in Fig. 1, but the design of sinter plants themselves will reflect the results of recent research and will include more extensive instrumentation.

Until recently sintering was used mainly to deal with fine ores imported from abroad, but a few years ago the Appleby-Frodingham Steel Co., which uses almost exclusively lean home ores from Lincolnshire and Northamptonshire, started a series of experiments on increasing the proportion of sinter made from these ores up to a 100% use of this material.[5] The results have been striking, furnace coke consumptions being reduced to as low as 17 cwt. ton—a figure generally associated with much richer imported ores. To the furnace coke consumption must be added the coke breeze used in the sinter plant (about 2 to 6 cwt. ton of iron according to the amount of sinter used), but this is a relatively cheap fuel compared with furnace coke.

Some of the ores used in the future, as at present, may not be suitable for sintering. A few works use briquetting plants of more or less standard brick-making pattern and also a considerable amount of work has been done on pelletising,[6, 7, 8] which may prove to be a suitable way of agglomerating ores which do not sinter well. Another method of agglomerating ores

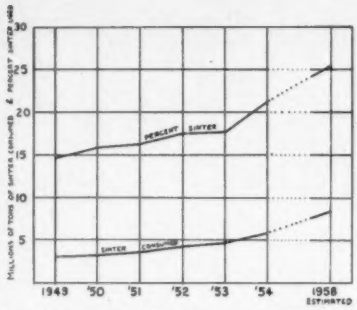

Fig. 1. Growth in the use of sinter in ironmaking, 1949 to 1954.

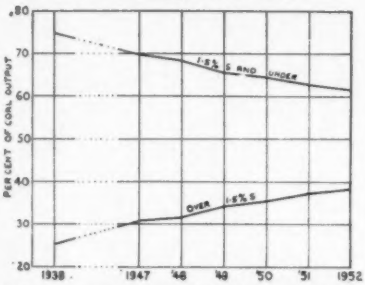

Fig. 2. Increase in the sulphur content of coal, 1938 to 1952.

is in a rotary kiln, but this seems to be of doubtful success, partly due to hard rings of agglomerate building up inside the kiln, and probably this method will not play a very important part in future development.

Blast furnaces and the future

It is evident, therefore, that the ore fed into blast furnaces in future will be much better prepared both as regard to size and composition. Whether the same will apply to coke is doubtful. The increasing size and height of blast furnaces demands stronger coke which will not crush under the great weight of the column of materials. So far research on coal blending and on the coking process generally seems to have just about kept pace with the slow deterioration in coking coal supplies, but greater proportions of inferior coking coals will have to be used for coking purposes in future.

An even greater problem will be sulphur. Fig. 2 shows the increase in the proportion of high sulphur coal mined in Britain in recent years. Since most of the sulphur in the iron comes from the coke, the sulphur content of iron will tend to increase. The 'classical' method of dealing with this is to operate a hotter and more basic (lime-containing) slag, but this increases the coke consumption and, if the coke is high sulphur, just aggravates the sulphur problem. In future there will be a greater tendency to deal with the sulphur after the blast furnace by one of the intermediate refining processes discussed later.

The tendency for the average size of blast furnaces to increase will continue. The biggest furnaces to-day have hearth diameters approaching 30 ft., and whilst this is perhaps approaching the upper economic limit, there are still many obsolete 10 ft. to 15ft. furnaces operating which will gradually be replaced by larger units. The question of furnace size is discussed in the Productivity Report on Iron and Steel,[9] and may lead to speculations as to what the ultimate size of blast furnaces will be. The advantage of size lies largely in economy of operating cost per ton, and since this is roughly related to the reciprocal of the diameter,* it follows that the savings to be obtained from making a big furnace still bigger are less than those to be gained by enlarging the small furnaces which remain. It is always risky to prophesy, but it seems probable that 25 to 30 ft. will be about the economic limit of size for some time.

Steel-making trends

For the last 80 years virtually only two processes have been used for the production of tonnage steels, *viz.* the Bessemer process, in which molten pig iron is converted to steel by means of a blast of air blown through it, and the Siemens open-hearth process in which scrap and pig iron (either solid or molten) are melted together and converted into steel by the oxidising action of the furnace gases, together with controlled additions of high-grade iron ore. In Britain the Bessemer process is used at only a few works, although it is relatively common on the Continent.

Other processes have, of course, been operated for the manufacture of the expensive alloy and tool steels made in relatively small quantities, for instance, a small amount of tool steel is still made by the crucible pro-

Table I. Production of Steel by the Principal Western Steel-making Countries in 1952

Method employed	*Production (millions of tons)*				
	U.K.	*U.S.A.*	*France*	*Belgium*	*West Germany*
Bessemer ...	1.13	3.1	6.6	4.2	7.1
Open hearth ...	14.16	74.0	3.4	0.6	8.2
Other processes ...	1.12	6.1	0.9	0.2	0.6

*The cost is not, as might be thought, related to $\frac{1}{D^2}$, because in large furnaces there is an inert mass in the centre due to incomplete blast penetration, so the effective hearth area is an annulus.

cess in which scrap and best Swedish pig iron are melted together in fireclay crucibles heated over a coke bed. Most of these high-grade steels are made in electric furnaces, either of the arc or high-frequency induction types. Steel for castings is still frequently made from scrap by melting it in a cupola and refining it by blowing a jet of air on to its surface in a small converter. However, the tonnage of steel made in these ways is relatively small, although, of course, with these special steels their money value is very high.

Table 1 shows the production of steel by the various processes in the principal Western steel-making countries in 1952, this being the latest year for which statistics are available in some cases.

The Iron and Steel Board's report points out that in the next five years more of the country's steel will be produced in integrated plant, that is, plant where the coke ovens, blast furnaces, steel furnaces, and rolling mills are all placed in the one works so that processing is continuous. This means there will be an increase in the use of molten pig iron in the charge for open-hearth furnaces, and this change might at first sight suggest that in future a higher proportion of steel than the present 6 to 7% will be made by the Bessemer process. Many outside the steel industry wonder why more use is not made of this process, which converts pig iron to steel without the use of fuel, whilst the open-hearth furnace needs a great amount of fuel. In earlier days one reason was, of course, quality—early Bessemer steel was of uncertain composition and properties compared with open-hearth. During the last 20 years such advances have been made in control of the Bessemer process[10, 11] that quality is no longer a governing factor. The main reason why the process is not used more is that it is not necessarily cheaper, in spite of the absence of fuel. In the Bessemer process the oxygen for combining with the carbon, silicon, and phosphorus comes from an air or oxygen blast which also burns some of the iron, and the yield of steel from pig iron is only 88% or so. In the open-hearth process, if correspondingly large proportions of pig iron are used (*i.e.* only a low percentage of scrap) the oxygen is provided partly by the furnace atmosphere but also by the addition of iron ore, or other forms of iron oxide such as mill scale. Thus the oxidation of the carbon, etc., gives an increased yield of iron from the ore charged, and the weight of finished steel may be over 100% of the pig iron and scrap used.

Thus if the value of the molten iron used in the furnace is taken as £13/ton and the cost of fuel as 6d./therm, it is clear that the 12% better yield of the open-hearth process more than pays for the fuel consumption of, say, 50 therms/ton. However, many other factors are involved, for instance, the capital cost of a Bessemer plant of a given capacity is less than that of an open-hearth plant; also, basic Bessemer slag is generally of higher 'soluble' phosphorus content and commands a better price as a fertiliser. In all, the economic balance of the two processes in this country is quite finely drawn.

A plant operating on the inland ironstone fields where ore can be dug cheaply from the ground around the works, but where imported fuel oil is dear, will have cheaper iron and dearer furnace fuel, so that conditions may well favour the Bessemer process. The reverse applies on, say, a coastal site in Wales or Scotland, where iron has to be made from expensive imported ore, but where fuel oil can be pumped direct from tankers into the works, and coalfields are near. Thus the extent to which Bessemer practice develops will depend largely on the future relative movement of ore, scrap, and fuel prices which it would be very rash to forecast.

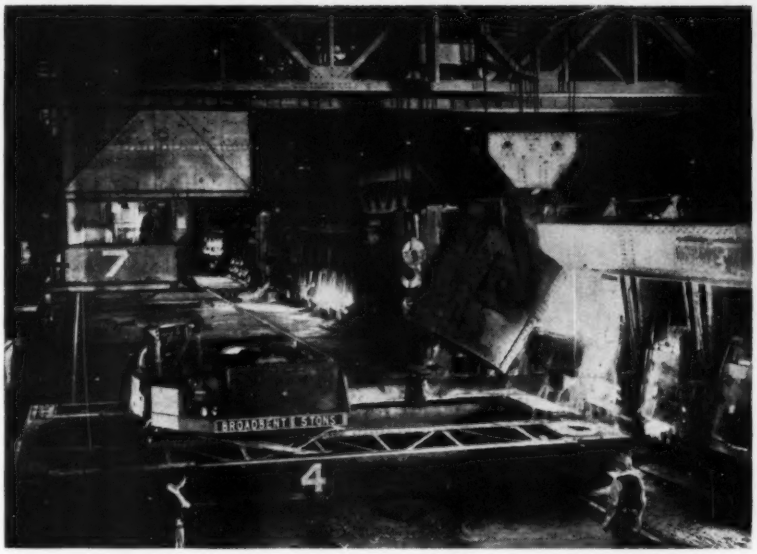

Fig. 3. Molten pig iron being charged into a tilting open-hearth furnace. The chute is removed when pouring is complete and the furnace door closed.

Fig. 4. A Bessemer 'blow' in progress. The initial lime charge is added to the converter by means of the chute seen above the converter mouth. The glare below is due to falling particles blown from the mouth of the converter.

Chemical and engineering problems of steel-making

Both the Bessemer and open-hearth processes have future problems which are of interest to the chemical engineer. The use of special blast mixtures and strict temperature control has solved the problem of high nitrogen content (due to absorption of nitrogen from the blast) which has plagued the Bessemer process so long. However, another problem which is still present is the loss of yield through 'slopping' or 'spitting,' when appreciable amounts of iron are lost from the nose of the converter. This loss is clearly shown in Fig. 4. Research on converter design and operation is needed to minimise this, as also is chemical research on the conditions causing 'slopping' (silicon content is one). For instance, by designing the converter nose 'off centre,' so that the outgoing gases are made to swirl, it might be possible to throw the larger particles which are on the point of ejection to the side, so that they fall back into the vessel.

The special blast mixtures referred to above are usually mixtures of oxygen with a nitrogen-free diluent such as carbon dioxide or steam. Pure oxygen is not used because the heat generated at the tuyeres is so intense that the bottom of the converter would be rapidly destroyed. However, a few years ago there was developed in Austria the so-called L-D (Linz-Dusenverfahren) process[12, 13] in which a jet of undiluted oxygen is directed on to the surface of molten iron held in a simple container. This has been proved to be very successful in providing high quality steel from iron of the correct composition for operating this process (high maganese and low phosphorus and sulphur), but it is not yet established whether it can operate on the wide range of irons which would be necessary for it to be regarded as of general applicability, and which are encountered in Britain.

In a continuation of this article, the author will go on to discuss the chemical engineering problems of stirring the metal and slag in the refining process, as well as the cold metal process, the desulphurisation of fuel, 'duplexing,' mixers and ladle reactions, reducing the silicon and phosphorus content of the steel, sulphur removal, and other problems, with, finally, some remarks on electric furnaces.

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The Widening Field of Chemical Engineering

(*Concluded from page* 210)

they can obviously only be outlined briefly in a review of possible fields of specialisation which a chemical engineer might follow. And here I would like to refer to Sir Christopher Hinton's comparison of the spectrum of chemical and civil engineering. He pointed out the wide spread of civil engineering and the number of specialist activities it embraces, all with a common educational background. He compared with this the way in which the spectrum of chemical engineering is widening and the need to anticipate the many specialised branches which are its future destiny. Clearly, the future undergraduate training in engineering must be concentrated on those parts of the basic sciences and mathematics which are relevant to its major activities and on the methods of their application to engineering problems, leaving the practical training to vacation courses and the initial years in industry. The other essential content of the academic course is to give the student some opportunity to grasp the essential part that research must play in development, and to understand how it must be integrated with management.

But with the widening of the spectrum and the inclusion of these borderline activities in the field of chemical engineering, three of which I have outlined, it seems to me that there is a new responsibility thrown on the chemical engineering departments to help in building a bridge between their own and the other departments concerned: microbiology, mining engineering and control engineering, and electronics. The existence of these bridges would enable postgraduate students who are attracted by the opportunities which these new fields offer to get the necessary training in a second range of techniques. I see clearly the need for postgraduate courses in a number of such borderline subjects in universities or colleges of technology selected for the dual opportunities they can offer. I am glad to know that some courses in biochemical engineering are already in contemplation. I realise that this will throw a heavier load on the departments of chemical engineering which can only be met by additional staff and facilities. That is one of the serious problems that the next decade has to face.

And with this inevitable growth of specialisation in the ever widening field of engineering, every major project becomes a combined operation in which the various techniques must all play a part. In view of this, it was encouraging to hear from the industrialists at the O.E.E.C. Conference* that one asset of the chemical engineer was his ability to understand the different points of view of his technical colleagues and thus to act as an effective co-ordinator of their contributions to his own field. In this connection, one of the happiest incidents of my year of office was the occasion when the three senior Institutions brought us into consultation with them to discuss the future of higher technological education.

I began by saying that we were travelling on the right road and can see the way ahead, and everything I have said since helps to justify that claim. More and more, the world will need chemical engineers, and our Institution has a great contribution to the future of Western civilisation.

*See page 218.

Dutch Chemical Firm's Golden Jubilee

The N.V. Chemische Fabriek 'Naarden' celebrated its Golden Jubilee recently. The company's story started in 1905 with the distillation of crude glycerine, and shortly afterwards the distillation of the essential oil from carraway seed was commenced. The company also began producing and trading in other domestic and foreign oils, and today its essential-oil programme encompasses several hundreds. Interest in further products for the perfumery and food industries increased over the years.

The growth of the undertaking can be seen by the fact that the initial capital in 1905 amounted to 800,000 guilders, whereas today this amounts to some five million.

Ore Dressing Research in India—1954

(Specially Contributed)

In April last year we published a critical review of published research on ore dressing in India in 1953. *Here is another, covering* 1954. *Ore-dressing research in India during this period has been characterised by studies on the beneficiation of pyrites, a mechanism for the depression of pyrites, the concentration of cassiterite ore by jigging and tabling, flotation of ferruginous manganese ore and alumina and work on vermiculite and sands.*

Pyrites recovery

IN India there is no deposit of elementary sulphur and the country has to depend on imports for meeting her industrial requirements of sulphur. Auriferous pyrites have long been known to occur in Wynaad, Nilgiris, Madras State. The concentration and cyanidation of auriferous pyrites samples from Harewood mine and Alpha mine, Wynaad, have been reported.[1–3] The Harewood sample was found to be highly mineralised and weathered and hence complex from an ore-dressing standpoint. It carried a total sulphur of 2.42% and the sulphides were, apart from pyrites, macasite, pyrrhotite and traces of chalcopyrite. The chief gangue minerals were quartz and magnetite, with minor amounts of calcite, haematite, felspar and chlorite.

Gold was found to be in a fine state of division and mostly associated with the pyrites. The pyrites particles were liberated at –65 mesh. The Alpha mine samples carried 1.46 and 1.7% sulphur and quartz, pyrophyllite, dolomite, magnetite and limonite as gangue. In the beneficiation of these samples, tabling in a laboratory Wilfly table has been done on the –35 and –65 mesh products, although high-grade concentrate could not be expected by the gravity method. The results are recorded in Table 1.

Tabling has been followed by flotation, but straight flotation yielded better results. Several reagents had been tried at different hydrogen-ion concentrations and other conditions. Owing to the presence of carbonates in the Alpha sample *A*, acid consumption has been found to be high. Some of the results are presented in Table 2 and the assay of the heads is the same as in tabling. Pine oil was used as frother and 0.3 to 0.5 lb./ton of collector, amyl or ethyl xanthate, was tried.

In another work on the flotation of a pyrites sample from the Chitaldrug district of Mysore, flotation in acid circuit has been found to yield a concentrate with 42.5% sulphur with a recovery of 86%; flotation in the alkaline range was comparatively less efficient.[4]

Table 1. Results of Beneficiation of Pyrites Samples

Sample	Head	Mesh size	Sulphur, %	
	Sulphur, %		Concentration	Recovery
Harewood	2.42	–35	6.78	63.7
		–65	6.05	63.9
Alpha *A*	1.46	–35	37.8	62.1
Alpha *B*	1.70	–28	39.3	72.7

Table 2. Pyrites Beneficiation—Flotation Results

Sample	pH	Reagent	Sulphur, %	
			Concentration	Recovery
Harewood	5.8	Amyl xanthate	30.2	55.0
	5.8	Amyl xanthate + ethyl xanthate	30.0	60.1
Alpha *A*	7.8	Ethyl xanthate	41.4	82.2
	7.9	" "	43.9	78.2
	8.2	" "	35.9	88.5
	9.3	" "	25.4	80.0
	8.0	Amyl xanthate	39.8	90.0
Alpha *B*	>7.0	Ethyl xanthate	41.7	92.9
	—	Amyl xanthate	46.0	93.1

Depression mechanism

In a study on the mechanism of depression of pyrites, it has been pointed out that depression by cyanide in presence of ethyl xanthate is due to the reduction of ferric ions on the mineral surface to the ferrous state so that ferric xanthate required for forming water repellancy is not formed.[5] In order to account for the depressing action of oxidising agents, the reaction between potassium dichromate and ethyl xanthate has been investigated.[6]

It has been found that with 0.8 g./l. of potassium dichromate and 0.2 g./l. of xanthate there is 46% decomposition of the latter. It is stated that the depression of pyrites by oxidising agents is due to the decomposition of the collector itself.

In the cyanidation of pyrites from Harewood mine it has been found that a recovery of 92% of gold can be obtained with 48-hr. agitation and with a consumption of 6.75 lb./ton of cyanide and 7.65 lb./ton of lime. The large cyanide consumption has been attributed to the presence of cyanicides in the ore. In the cyanidation of the non-magnetic fraction the gold recovery has been 93.4%. Lead acetate acts as accelerator at 0.01% concentration, bringing down cyanide consumption to 3.92 lb./ton and giving a maximum recovery of 94.6% of the precious metal. Cyanidation after calcination at 650°C. yields a gold recovery of 96.52% with a consumption of 0.21 lb. of cyanide and 0.053 lb. of lime per ton of ore. Straight cyanidation of the Alpha *A* sample recovers all the gold, but the metal content of the ore is too low for economic recovery.

Gravity and magnetic methods

In view of the paucity of tin ores in India, the existence of a stanniferous mineral belt extending over 20 miles at Paharsingh, near Ranchi, Bihar, is considered significant.[7] The belt con-

sists of parent deposits, alluvial deposits and eluvial deposits. The recovery of tin from the low-grade eluvial deposits carrying 0.205% tin with quartz, tourmaline, mica, felspar and limonitic clay as gangue was undertaken.[8] Jigging of the +4 mesh fraction in a Denver mineral jig gave a concentrate of 0.479% tin with a recovery of 85.9%. Straight tabling of the coarse sand gave a concentrate of 57.45% tin and a recovery of 74.5%. Jigging followed by tabling of the +4/10 mesh fraction gave a concentrate of 62.15%, while the –10 fraction yielded 65.13% grade. The total recovery of tin was 77%. It is believed that the return of middlings may improve the recovery to 85%.

Manganese ore beneficiation

In the beneficiation of ferruginous manganese ore containing 33% Mn and 26.4% Fe, obtained from the Keshapur mines of Mysore State, magnetic separation and froth flotation have been employed.[9] The magnetic separation of the –60/100 size fraction in a laboratory-type magnetic separator was preceded by conversion of the non-magnetic haematite to magnetite by roasting at 600°C. with 10% of charcoal. There was manganese enrichment in the non-magnetic fraction which showed 51.7% Mn and 7.3% Fe. Reheating the non-magnetic portion in hydrogen at 750°C. for 1 hr. enhanced the percentage of manganese in the final product to 54.2. The flotation of the ore with oleic acid and pine oil has been investigated with various modifiers. Sodium sulphide has been found to be a good depressant giving a float with a Mn/Fe ratio of 2.45 at *p*H 9.5. An increase in *p*H to 11 showed an increase of the ratio to 4.53, though the total amount of manganese floated fell down considerably. It has been concluded that, for this ferruginous manganese ore, magnetic separation offers greater scope.

The flotation of alumina and the depression of silica have been studied with a Kashmir bauxite sample assaying 58.76% Al_2O_3 as diaspore and 18.94% silica, besides titanium and ferric oxides.[10] Heavy-media separation with acetylene tetrabromide suggested that the –100/250 mesh fraction was best suited for flotation studies. Using 2.5 lb./ton of oleic acid, 1 lb./ton of pine oil and 1 lb./ton of kerosene as promoter, a float assaying 66% Al_2O_3 has been obtained at *p*H 10. The recovery was nearly 62%, though a slightly higher recovery of 65% was obtained by employing 1 lb./ton of sodium silicate in addition.

Mica and sands

Vermiculite is a mica-like substance that finds many industrial applications. The best samples bulk to less than 6 lb./cu.ft. after being exfoliated, but Indian samples from Rajasthan and Mysore have been found to give a bulk density of more than 12 lb./cu.ft. These samples have therefore to be upgraded before they can be successfully utilised. Heavy-media separation and tabling have been done in different size fractions. The best product that has been obtained bulked to 9 lb./cu.ft. and the recovery of the mineral is reported to be good.[11]

Gravity methods have been applied in the separation of quartz sand from associated minerals as magnetite, rutile, ilmenite, hornblende and zircon. Heavy-media separation with bromoform, specific gravity 2.89, removed the heavier contaminants, leaving clean sand. Tabling also gave good products with less than 0.1% impurities and the recoveries ranged up to 90%.[12] The mining and dressing of the titanium minerals ilmenite and rutile, found in the beach sands of Travancore-Cochin, by magnetic and high-tension electric separators, have been fully described.[13] Electromagnetic separators of the 'lift' type give a 98%-pure ilmenite in the magnetic fraction with minimum entertainment of non-magnetic impurities. The non-magnetic fraction contains all the rutile which is concentrated by high-tension electric separators, employing 20,000 to 30,000 v., depending upon conditions of feed and humidity. The final rutile concentrate contains a maximum of 0.5% ilmenite and analyses to 96% TiO_2. Ore microscopic characters of the vanadium-bearing titaniferous iron ores of Mayurbhanj, Orissa, have been determined.[14] Among other work, mention may also be made of the soap flotation of beryl and beach sands.

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British Standards

Forged steel pipe fittings. A new standard applies to the following forged carbon and alloy steel screwed fittings for assembly with pipes screwed in accordance with American Petroleum Institute Standard 5-L, 'Line Pipe': 45° elbows; 90° elbows; tees; crosses; laterals; caps; bull plugs; hexagonal, square and round head pipe plugs; couplings; reducing couplings; hexagonal head bushings. The range of sizes is from $\frac{1}{8}$ in. to 4 in. and 6 in. and the range of ratings from 600 to 1,500 p.s.i. within plot limits. Dimensions, tolerances, materials and marking are specified. (B.S. 2561:1955 'Forged steel pipe fittings, screwed with A.P.I. thread for the petroleum industry', 3s. 6d.)

Glass pipelines and fittings. This new standard was prepared by a technical committee representative of the manufacturers, interested scientific bodies and users in the chemical, food and allied industries. It covers pipeline from $\frac{5}{8}$ to 18 in. nominal diameter, and specifies maximum working pressures, standard lengths, limits on ovality and on the angle between ends and axis. The fittings described and illustrated comprise seven types of bends, tees, crosses and reducers. The dimensional requirements of buttress ends and backing flanges are given in detail in order to ensure interchangeability. (B.S. 2598: 1955, 4s.)

Cresylic acids and phenol. A series of five British Standards dealing with cresylic acids and phenol has been revised to bring the specification up to date, particularly with regard to methods of test. These methods of test are based, as before, on those recommended by the Standardisation of Tar Products Tests Committee (S.T.P.T.C.) in their 1950 edition of 'Standard methods for testing tar and its products'. The revised standards cover 'Cresylic acid of specified ortho-cresol content' (B.S. 517 : 1955, 5s.), 'Cresylic acid of specified meta-cresol content' (B.S. 521 : 1955, 5s.), '*Ortho*-cresol *meta*-cresol and *para*-cresol' (B.S. 522 : 1955, 3s.), 'Phenol' (B.S. 523 : 1955, 3s.), 'Refined cresylic acid' (B.S. 524 : 1955, 4s.) In British Standards 517, 523 and 524, the 'specification' clauses remain unchanged from the 1948 edition. In B.S. 521, the five well-established grades of cresylic acid have been redefined so that the maximum meta-cresol content for Grade A is now 60 per cent. In B.S. 522, a third grade (Grade C) of *ortho*-cresol has

been added.

Welded storage tanks. A new standard relates to the design and construction of mild steel fusion welded horizontal storage tanks with dished and flanged ends complying with Table 4 of B.S. 1966 ' Domed ends for tanks and pressure vessels ' and also to tanks with unflanged outwardly dished ends. The sizes of tanks range from 3 ft. 6 in. diameter by 4 ft. nominal length up to 9 ft. diameter by 30 ft. nominal length. B.S. 2594 specifies requirements for tanks of adequate safety and reasonable economy, in a range of sizes to suit the requirements of user industries. These tanks are intended for the static storage of liquids which are not corrosive to mild steel. (B.S. 2594 : 1955, ' Horizontal mild steel welded storage tanks ', 4s.)

Rumania's Chemical Industry

INCREASED EXPLOITATION OF MINERAL DEPOSITS

(Specially Contributed)

THE upsurge taken by industry in Rumania in the years following the second world war, the creation of new industries for producing machinery and electrical equipment, the construction of thermo- and hydro-electric stations as well as the important State investments that made it possible to turn to account the country's mineral deposits, have created favourable conditions for the development of the chemical sector, which in the past was limited almost exclusively to products of the mining and oil industries.

Rumania's raw material resources are vast and various. Being an oil-producing country, the processing of petroleum offers huge possibilities for the production of organic synthesis products and especially of synthetic rubber, plastics, solvents, synthetic fibres, plasticisers, detergents, insecticides, etc. Methane gas provides a rich source of raw material for the production of nitrogen, carbon black, the products of heavy organic synthesis, solvents, plastics, synthetic fibres and synthetic rubber.

Another raw material found in great quantities in Rumania is coal. From plants set up in recent years for obtaining chemicals from coke-oven gas, a rich range of aromatic products are being obtained, among which are toluene, xylenol, benzene, naphthalene, anthracene, etc. The distillation of brown coal provides further quantities of organic chemicals including intermediates for the pharmaceutical industry.

The inorganic chemical industry has inexhaustible reserves of salt for the large-scale production of sodium, chlorine and their by-products, while the reed found in considerable quantities in the Danube Delta provides the basis for a cellulose industry. The manufacture of paper, viscose, and artificial fibres is undertaken, as well as furfural.

New chemical projects

New constructions commissioned in recent years include the B. Berea chemicals factory, the ' Electrochim ' plant for producing abrasives and electrodes and the ' Argesul ' tanning products factory. Some existing works have been completely re-equipped and to some extensions have been added, which turn out potassium dicromate, carbon black, formic and oxalic acids, phenols, plastics, nitro-calcite and other products.

Plants have also been commissioned to produce (experimentally) fatty acids from paraffins and for the chemical treatment of methane gas.

At present, work is under way for the completion of, among others, an antibiotics factory, a fertiliser plant, and a plant for the production of sodium products.

In the 1953-54 period three modern units were created for the turning out of mineral, nitrate and phosphate fertilisers. In the same period installations were completed for the production of insecticides and pesticides.

Expanding production

The systematic development of the chemical industry is illustrated by the sharp increase in production in the 1948-54 period. In 1954, Rumania's chemical production was 6½ times greater than in 1938 and 6.6 times greater than in 1948. The output of sodium products increased 2½ times, that of glue 3 times, of ammonia 13 times, carbide 4½ times, acetic acid 14 times and paints and dyestuffs 7 times. Nineteen times more phosphate fertilisers were produced than in 1948, 6 times more sulphuric acid and 6 times more carbon black.

The pharmaceutical industry, which was limited in the past to certain laboratory installations based on cosmetics, has now greatly developed. In 1954, some 400 types of medicines were produced. A number of new products have been manufactured in the past few years, and important progress has been achieved, also, in the production of sulphamides and vitamins.

Of recent date also is the dyestuffs industry, created in 1948. Since then, 50 types of dyestuffs and 20 intermediary products have been produced. The development of dyestuffs production is reflected in the following annual production indices for 1948 to 1954 inclusive: 100, 200, 300, 400, 500, 650, 750.

Significant for the further development of the chemical industry in Rumania is the fact that at present this industry is in a position to export quite a number of chemical products. In latter years, Rumania has exported soda ash, sodium bicarbonate, sodium silicate, solvents such as butanol, amyl acetate and butyl acetate, mineral acids and their salts, carbon black and furnace black, ultra-marine blue, mineral pigments for the dyestuffs industry, abrasive materials, pharmaceutical products, aspirin, salicylic acid and glucose.

The importing countries have been (in alphabetical order) Albania, Austria, Belgium, Bulgaria, China, Czechoslovakia, Egypt, Finald, France, Germany (East and West), Great Britain, Hungary, Holland, Israel, Italy, Korea, Lebanon, Poland, Syria, Switzerland, Turkey, and the U.S.S.R.

In 1955, Rumania is offering for export furfural, oxalic acid, electrode paste and anodic material for the electro-metallurgical industry, castor-oil, aniline dyestuffs for cotton, wool and leather, lacquers and dyestuffs of all kinds, coloured earth, new varieties of carbon black, catgut, etc.

The pace of development of the chemical industry is expected to lead, in the near future, to a wider range of products and a quantitative and qualitative increase of the existing products.

To Authors

The Editor welcomes practical articles and notes on chemical engineering and related subjects with a view to publication. A preliminary letter or synopsis outlining the subject should be sent to the Editor, CHEMICAL & PROCESS ENGINEERING, *Stratford House, 9 Eden St., London, N.W.1.*

Conference on

THE FUNCTIONS AND EDUCATION OF THE CHEMICAL ENGINEER IN EUROPE

Postgraduate and part-time courses for chemical engineers; practical training; research

This second part of our report on the recent O.E.E.C. Conference in London—the first part appeared in May—covers the fourth, fifth and sixth sessions, with the final summing up.

FOURTH SESSION

Chairman: Prof. F. H. Garner, O.B.E. (*Birmingham University*)

'Chemical Engineering Education in Sweden at University Level,' by C. J. Borelius (Svenska Skifferolje A.B., Sweden).

A review is presented of a report, issued by the Education Committee set up by the Association of Swedish Engineers in 1953, on chemical engineering education at the Royal Institute of Technology in Stockholm and the Chalmers Institute of Technology in Göteborg. In the report the scope and disposition of unit operations as a subject of teaching are discussed. At present the full professorships in unit operations are vacant at both schools. Ways to find qualified applicants for these positions are discussed. Further special curricula for the education of chemical equipment designers are suggested.

'The Co-ordination and Development of Postgraduate and Undergraduate Courses in Chemical Engineering,' by Prof. M. B. Donald (University of London) and Prof. J. M. Coulson (University of Durham).

This paper shows some of the reasons for and advantages to be obtained by taking one of the postgraduate courses. They will require time and the real decision is whether in the eyes of industry the time is most profitably spent in this way. In Britain it is at present much easier to obtain financial assistance to carry out research in the original subject of one's undergraduate course than it is to obtain assistance for continuing one's studies in a separate course. This is most unfortunate since it is dangerous to tackle technology without a basic knowledge of engineering science and we must be prepared to pay the price for a longer training.

The final developments of the techniques of chemical engineering such as fluidised beds or complex distillation processes require a combination of chemistry, chemical engineering and mechanical engineering and it is a great asset to have several men trained in any two of these fields.

'Process Control in a Chemical Engineering Course,' by Prof. S. G. Terjesen (Institut for Kjemiteknikk, Tekniske Hogskole, Norway).

In addition to its direct usefulness, process control serves an important educational purpose. Intelligent consideration of instrumentation and automatic control presupposes a thorough knowledge of the plant and process, and forces the student to look at his project more from an operational point of view. It is certainly not the object of the teacher to clutter up the student's mind with more or less superfluous knowledge, but to develop in him valuable attitudes and patterns of thought. There can be no doubt that as a pattern of thought for an engineer the theory of automatic control ranks very high indeed, and that a chemical engineer who can think in terms of closed loop systems is a better man than one who cannot.

'The Part-Time Course in Chemical Engineering,' by R. W. Blount (Staff Inspector for Chemical and Metallurgical Education, Ministry of Education).

The place of the part-time course in the educational system of Great Britain and its importance in the training of the professional engineer are discussed. Details are given of the Scheme for Higher National Certificates in Chemical Engineering, and of the relationship of these certificates with the examination qualifications for the grades of membership of the Institution of Chemical Engineers.

'The Examination of the Institution of Chemical Engineers,' by G. U. Hopton (Senior Research Chemist, North Thames Gas Board).

The examination of the Institution of Chemical Engineers is divided into three parts. The first consists of four papers on the principles of chemistry and physics, and elements of engineering. The third is the home paper, an exercise in chemical process plant design. These three parts qualify candidates for admission as students, graduates and associate members respectively. An account is given of the syllabus for the examination, and of the nature of the home paper.

Discussion

The chairman said it should be borne in mind that there were various types of postgraduate courses. There was a distinction between the immediate advanced postgraduate course and the type of course attended by men who had been in industry for a few years after graduating and then came back for another course; the men who attended that second type of course had the advantage that they were more mature than when they were at the university and they had been able to make up their minds. Another important matter in connection with the second type of course was that unless they were considered by industry to be valuable they would be discontinued, for those attending would require support from industry; that was a most valuable test as showing industry's assessment of the value of such courses.

Mr. H. G. Davey outlined the nature and functions of the chemical engineer and said that in a course devised to train the chemical engineer the following subjects were essential: applied physical chemistry (the adaptation of classical physical chemistry to practical circumstances and conditions, special emphasis being laid on those parts of the subject which had the most general application, *e.g.* heat transfer, electrolysis, etc.); methods of measurement and instrumentation; corrosion and erosion; materials of construction; plant design and layout; the Factories Act and Chemical Works Regulations; works organisation and management, with brief reference to trade union principles and practices; handling of personnel; safety; and costs.

Mr. S. A. Gregory discussed part-time study and the way in which apprentice chemical engineers were likely to grow up in the works, and emphasised the need for them to learn lots of physics.

Mr. E. Higgins (Transport & General Workers' Union) said he believed the chemical engineer was accepted as being a member of the management. He would be in charge of the work of fitters, process men, etc., and he would require not only technical knowledge, but also knowledge of human beings. Thus, he would need training in industrial relationships. That training should be given at the technical college or university, and should be a continuous process; it should not consist of a few brief lectures, and it should also be part of the training in postgraduate courses and refresher courses.

Mr. E. A. Watson (West Ham College of Technology) said the chemical engineer had to be a paragon, a perfect know-all. That implied versatility. Man was basically a versatile animal and could adapt himself, and so long as he had fundamental understanding to work on, the ability would grow, given reasonable intelligence. That meant that the basic requirements of the chemical engineer were a knowledge of all the sciences with which he was to come into contact. Mr. Watson put rather more stress on mathematics than did some of the earlier speakers. As to the basic jumping-off point for the chemical engineer, he questioned whether that really mattered; in his view it was rather an attitude of mind than anything else. The chemical engineer was working in a specialised field, although the number of specialities was more or less infinite; but it was the fundamentals that mattered.

Mr. J. K. A. Parkin, commenting on the recent decision of the Institution of Chemical Engineers to revise its examination, said he felt that that revision should be a pointer to those friends from the Continent who were still fighting very hard for the recognition of what in Britain was called ' the chemical engineer.'

Mr. D. Scott, a third-year student taking a final degree course in chemical engineering at a technical college, a three years' course, said the extent of the course could be gauged by the fact that students in other branches of engineering tended to consult the chemical engineering students on their problems.

Prof. Donald, in a brief comment on the discussion, said the endeavour was to arrange the undergraduate course so that the chemical engineer had the same general education as other engineers and achieved a very high standard in chemistry and chemical engineering as well.

Mr. Davey said that in Britain the great majority of students taking National Certificate courses in chemistry came from works laboratories, and when they were going on to the H.N.C. courses, if we did not do something about it, their practical work would not be appropriate to their studies. He felt there was no hope for the success of the Higher National Certificate in chemical engineering unless employers and teachers came together to ensure that the practical work that had to be done was appropriate.

Mr. Blount agreed with Mr. Gregory's remarks on physics, and he was happy that the physics content in many cases had been increased by as much as 50%. If the industrialists could help in their local colleges, the Ministry of Education would be grateful.

Maybe in some cases the facilities for practical work were not available. In the National Certificate courses there must be regular and progressive practical work; whether it was done in college or in industry he did not mind, but unless it was done the course could not be accepted as a National Certificate course.

The chairman, summing up the discussion, said one of the most important advantages of the conference would be an appreciation of thought in other countries, and for that reason the paper by Mr. Borelius, of Sweden, was of special value.

Attention had been called by Profs. Donald and Coulson to the decline in the number of students willing to take postgraduate courses as the undergraduate courses developed. That was a logical development; and Prof. Newitt had made a very good point on the previous day, that so far as civil, mechanical and electrical engineering were concerned, no one had suggested that the basis should be a postgraduate course following an undergraduate course in physics. Certainly neither industry nor the engineering institutions would welcome such an alternative in the accepted procedure.

The real alternative to a degree in pure science or engineering with a one-year postgraduate course in chemical engineering would be to lengthen the chemical engineering course to include the postgraduate year, so that a more complete course in chemical engineering could be given, together with a relaxation of present requirements to give opportunities for other activities—cultural and so on. However, that lengthening of the course could hardly be justified at the present time, in view of the shortage of chemical engineering graduates.

Mr. Blount had given an interesting account of a part-time course in chemical engineering for students who missed the opportunity to go to a university. Students engaged in industry approached problems from the point of view of apparatus and plant which they knew, and hence the method of teaching them required to be different from that of the university students, who had a more theoretical approach. It would be of very great interest to follow the future of sandwich courses which were now being started in a number of branches of engineering.

At the fourth session, he concluded, the spectrum had been extended down to the technicians and, as shown in the papers of Mr. Blount and Mr. Hopton, in Britain they liked to make it possible at any stage in a man's career for him to have adequate training to enable him to develop his abilities to the fullest possible extent.

FIFTH SESSION

Chairman: Prof. M. Letort (Directeur de l'Ecole Nationale Superieure des Industries Chimiques, France)

' The Practical Training of the Chemical Engineer on Entry into Industry,' by F. H. Pugh (N.V. De Bataafsche Petroleum Maatschappij, Netherlands).

A description is given of the method followed by the Royal Dutch/Shell Group in the Netherlands for the training of newly engaged graduates as chemical engineers. The training is carried out at the Pernis refinery (including chemical plants) of N.V. De Bataafsche Petroleum Maatschappij (B.P.M.), the Amsterdam and Delft Research Laboratories and the Hague Office. Chemical engineers are trained as refinery engineers; petro-chemical plant engineers, engineers for the development department of the Hague office for process development in refineries and chemical plants, and development of processing equipment. Specialists such as materials and corrosion engineers and instrumentation engineers are also trained.

' Practical Training of Chemical Engineers—A Proposed Postgraduate Apprenticeship,' by J. P. V. Woollam and J. M. Solbett (Simon-Carves Ltd.).

The paper discusses the relative merits of the means for

the practical training of full-time chemical engineering students during a pre-university year in industry and during the summer vacations. A summary is given of the views of a number of university and college departmental heads.

For postgraduate training the paper urges the acceptance of a two-year apprenticeship scheme as a necessary qualification for professional recognition. The object of such organised training would be to bridge at an early stage the gap between the outlook of new graduates and that of the great body of established practical men engaged in industrial supervision.

A postgraduate apprenticeship scheme applied to a chemical plant contracting company is described. The training includes progressive supervised work in the drawing office, on plant operation, plant construction and commissioning, and, finally, in the design office. The emphasis should be on constant guidance of the trainee by a senior chemical engineer for the purpose of co-ordinating the various activities of the apprentice.

'Vacational Training for Chemical Engineers,' by D. Morten (Shell Refining and Marketing Co. Ltd., United Kingdom).

This paper gives details of a well proven scheme for the vacational training of technical undergraduates, especially chemical engineers, in the petroleum refining division of British industry. The advantages gained from experience in extending this scheme to European and other nationalities on a student exchange basis is discussed, and the part that vacational courses can play in the development of the student not only from the technical but from the human point of view is stressed. The advantages gained by tutored courses working on selected practical works problems are also dealt with.

'Foundation and Development of the International Association for the Exchange of Students for Technical Experience,' by J. Newby (Secretary, I.A.E.S.T.E., United Kingdom).

In this paper the organisation and development of I.A.E.S.T.E. during the past six years is traced and stress is laid on the advantages obtained by students and industries participating. The type of training for students of chemical engineering is referred to and typical examples of training offers available in various industries in Great Britain and abroad are quoted. The paper also includes international statistics for students of chemical engineering covering the years 1950 to 1954.

Discussion

Dr. E. H. T. Hoblyn (director, British Chemical Plant Manufacturers' Association) pointed out that British chemical plant manufacturers had always taken a very lively interest in the education and training of chemical engineers; a question so vital to the industry's development. He had an infinite faith in the policy of the B.C.P.M.A. in trying to play its part in the training of the men who were so badly needed.

Speaking of works' courses of training, he said they must be planned and properly supervised, and if university teachers could play their part within those courses, so much the better. Secondly, the courses must be so designed that they not only developed the man as a chemical engineer, but smoothed down some of the academic edges and helped him to fit into the industrial team. One liked to see experience gained by working on the job, as a plant operator or in the erecting shop of the chemical plant manufacturer. There was much more in that than just gaining practical experience. He felt very strongly that life was not so short that at least one or even two vacations could not be spent in that way; getting close to the job and, better still, getting close to the man, learning something of the worker's outlook on life, how he thought and worked out his problems and, above all, how he got on with them. Also the young chemical engineer was brought into first-hand contact with accident prevention and fire prevention as practised in the chemical industry. He could not be made aware of those aspects of his responsibilities too soon; only in the works could he gain that awareness, and it should be learned as quickly as possible. It was something which ought not to be learned the hard way, because that could be the fatal way.

Mr. F. E. Warner (Joint Hon. Secretary, Institution of Chemical Engineers) emphasised the prime importance of plant operation; the experience gained by starting up and shutting down a plant, for example, was necessary to the man who had to design a plant. Commenting on the considerable degree of mutual distrust which had existed in the past in the industry, he said the picture was changing, thanks largely to the beneficial influence of the home refining of petroleum and the construction of new oil refineries. There was a pointer for co-operation in other branches of the industry.

Among the young people training for Higher National Certificates we had a reserve of students who were already getting their practical training in industry. There was a great responsibility on everybody in industry to see that men from the drawing office or the laboratory go on to the process plant.

Dr. W. S. Norman pointed out that to be able to think quantitatively was most valuable in studying flowsheets, in finding out the bottle-necks; the chemical engineer gained by the ability to deal with those things quantitatively. Dr. Norman urged that initial training should not be too rigid.

Mr. S. A. Gregory, discussing part-time students, said that in order to obtain deferment it was obligatory to set out a course of training in industry, and he hoped many of the considerations put forward in connection with other types of training would influence the suggestions which he felt should be made, say, by the Institution of Chemical Engineers regarding suitable industrial training for part-time students. A range of possibilities should be indicated, which was the more important because already we were facing problems in dealing with the deferment boards on the sort of training given. We must give more thought to the matter in order to be able to use the new reserve of people who could enter the chemical engineering profession.

Mr. R. G. Browning, introducing a note of caution about the teaching of the chemical engineer, pointed out that every year he had more and more to learn. By the time he had qualified and had completed his national service he was 23 years old, or perhaps 24, and he had the problem of acclimatisation in industry before he felt his feet as a chemical engineer.

Mr. W. G. Daroux suggested that there was perhaps over-emphasis on drawing office training. He would take all the drawing office paper away; a man should be able to outline by a simple sketch the main dimensions of equipment. Also he pointed out that the empirical approach gave results which were interesting and important.

Prof. P. D. Ritchie (Glasgow Technical College) mentioned a scheme which had operated in Glasgow since 1947 for introducing practical experience at undergraduate level.

In the fourth year of the four-year course the work was

so arranged that by the time the summer term began the lecture work, etc., was finished, and each student was allocated a research project for the remaining 12 or 13 weeks, either as an individual or as a member of a team. Thanks to extremely good co-operation by industry, two works practice schools or stations had been established. One of them was in the Ardeer factory of I.C.I., where the students went into residence. They worked during the day on the problems allocated to them, and in the evenings there were discussion groups. They were given problems on a works scale; for example, heat transfer problems in cooling towers.

Monsieur J. Gerard spoke of the European Federation of Chemical Engineering, membership of which includes various bodies in a number of Continental countries.

Mr. J. M. Solbett, replying to the discussion on matters relating to the paper by Mr. Woollam and himself, said they agreed that postgraduate training courses should not be rigid, but must be suited to the individual needs, not only of the companies concerned, but also of the chemical engineers, and there should be close and continuous personal supervision.

Mr. D. Morten said his firm did believe that in practical training there must be some urgency and purpose, and it was important that there should be some reports. If the courses were too perfect and everything was laid on, it became simply a succession of experiments. It was desirable that the students should do something on the plant; they should be able to shut it down, put in thermometers and so on.

The chairman, summing up the discussion, said that no one doubted the usefulness, perhaps even the necessity, of the various stages of work for the student engineer during his initiation into industry; and as the director of a school he had noted very clearly the great advantage of industrial training. It must be borne in mind that young students knew nothing of factories; they were not well informed of the conditions of working in industry, and the advantage of contact with industry for a month or two was evident in their subsequent studies. Industry was now conscious of its special role in that regard and recognised that it was necessary to work with the universities and schools, not against them.

Again, many references had been made to the importance of not having too rigid a programme of training in industry, that it should not be like military training, that it was important to preserve the spirit of initiative in the young men. That created a new problem which we should all have to think about; we had to choose the middle way between the realism which was necessary in industry and the mental freedom of the university.

The fact that industry was conscious of its special role and was ready to play it would be to its advantage in the future, for it would partially solve the problem of the shortage of engineers.

He welcomed the exchange of experience resulting from enabling students to work for a time in other countries; in addition to the experience they gained, they came to feel that they were citizens not only of their own countries, but also of Europe.

SIXTH SESSION

Chairman: Sir Harold Hartley

'Research in Chemical Engineering,' by Prof. J. Cathala (director, Institute of Chemical Engineering, University of Toulouse, France).

Chemical engineering has established itself as a true science now that the importance of the concept of the 'fundamental operation' has been acknowledged. The detailed study of major fundamental operations has stimulated a considerable amount of work during the last 30 years. The accelerating development of the chemical industry is calling for new research every day.

The growing number of fundamental operations being used in chemical engineering can usefully be classified in three main orders: 'mechanical operations,' 'process of physical change' and 'process of chemical change.' This classification permits certain comparisons and suggests methods of study for enabling fruitful research to be conducted. On the other hand, for the study of its particular problems, chemical engineering must have recourse to methods of investigation which were at one time little in evidence: calculation by graphs, dimensional analysis, statistical analysis, etc. . . . Some research is necessary to augment the strength of these methods.

In fact, for the solution of a particular problem chemical engineering often finds itself up against an almost total absence of numerical data on the properties of the substance being dealt with. It is indispensible to develop approximate methods for estimating these missing data.

These problems can only be resolved by co-operation, in a single study, of several specialists. It is equally indispensible to organise co-operation between teams of investigators. Among teaching establishments, which must not confine themselves only to teaching, this co-operation ought not to be difficult to organise. Industry, which possesses much more powerful means of investigation, must not stand aloof from this work of common interest.

Industry ought not to reserve for itself the privilege of conceiving, calculating and working up new procedures. Teaching establishments can play an equally important part in this domain where successful research can be an important asset.

'Organisation of Research in the Process Technology Field in Germany,' by Dr. H. Miessner (Farbenfabriken Bayer A.G., Germany).

Chemical and process engineering research is carried out in Germany, as well as in industry, in the institutes of the Technische Hochschule and universities.

Through the efforts of Eucken, R. Plank and others, the leaders of industrial and academic research have since 1932 joined together in the Fachgruppe Verfahrenstechnik (Chemical and Process Engineering Group) of the Verein Deutscher Ingenieure (Society of German Engineers) in order to exchange their research results in regular working symposia and to arrange the carrying out of new tasks. Corresponding to the broad scientific basis of chemical and process engineering, chemists, physicists, physical chemists and engineers are represented on the 13 technical panels of the Group.

The Process and Chemical Engineering Research Association, which erected its first Research Institute in Aachen in 1952, works in close association with the Process and Chemical Engineering Group. This institute is supported by industry, technical societies as well as the Lands and Federation. Further institutes are planned. They will be supported by means provided by industry, technical societies, Federation and Lands and will serve almost exclusively research purposes.

'Chemical Engineering Research: Its Future Needs and Scope in Process Development,' by A. S. White (Head of the Chemical Engineering Division, Atomic Energy Research Establishment, United Kingdom Atomic Energy Authority).

The chemical engineer, engaged on process development

with the object of producing flowsheets and basic data for full-scale plant, requires, *inter alia:*

(1) Physical and chemical data on the materials used in the process.

(2) Design methods for full-scale plant. These may be methods based on his own experiments, his own experience or the accumulated experience of a specialist firm, or they may be based on basic or fundamental research in universities or research establishments.

(3) The development or adaptation of ancillary plant items.

Physical and chemical data are specific requirements for his immediate job and are frequently not available in the literature. He must therefore arrange for the data to be obtained in his own organisation, preferably getting chemists or physicists to do the experimental work. Although in the last resort he must do it himself, *e.g.* equilibrium data in distillation problems.

The development of design methods is not really part of his main job, but he often finds that existing methods are inadequate and require extrapolation beyond the limit of prudence, *e.g.* they cover ranges of variable too narrow for his purpose. Recourse has therefore to made to *ad hoc* experiment or to the pilot plant. Here is scope for the universities but the facilities of the universities are circumscribed and there is scope for much work by industry itself or by sponsored work in research associations or institutions.

Equipment development may have little of the research element, although there is scope for research and inventiveness, and it is perhaps a function of the equipment maker rather than of the basic researcher. However, a knowledge of the mechanism of the operation must be of service in promoting advance, and this provides a field for research proper.

The development of nuclear engineering, which introduces new materials, and requires new and novel processes, has had to meet all these requirements, has demonstrated the paucity of information available for the design of equipment for some of the so called unit operations. It has therefore provided an incentive for basic research in many fields and the results have a much wider significance.

' Future Needs of Chemical Engineering Research,' by Prof. S. Kiesskalt, director, Research Institute for Process Technology of the Rhine-Westphalian Technische Hochschule, Germany).

Developments in all fields of chemical technology are towards continuous processes with higher pressures and higher temperatures and also higher flow densities, so that smaller units with shorter and more closely defined plant occupation times can be used. One obtains thereby, also in respect of quality, more regular products and can use such valuable materials as silver, tantalum, titanium and molybdenum alloys sparingly in the construction of special plant items. The development of such plant items, including means of isolation and delivery pumps, is a special branch of research (coil tubes, high pressure packings, hydraulic working diaphragm pumps, etc.).

In plant apparatus, we still lack plant-scale ultracentrifuges for the separation of solid-liquid and liquid-liquid compact diffusion apparatus, the full utilisation of cavitation, the further development of ' Grossofen ' and the atomic pile to real continuous plants.

' Some Remarks on the Scope and Future of Research in Chemical Engineering,' by Prof. Dr. Ir. P. M. Heertjes (Nijrerheids Organisatie T.N.O., Netherlands).

The first aim of research in chemical engineering is the increase of knowledge so that a direct calculation of the dimensions of a chemical plant will be possible. Present research in chemical engineering must be of at least three distinct types: fundamental research, equipment research, and development. Great attention to fundamental research must be paid in the future. This will necessitate better equipped laboratories and better paid staff.

It is advocated that the financial policy for research should be on a long term basis and that the research worker should have greater freedom, especially in industry, than at present.

' The Scope of Research in a University Chemical Engineering Department,' by Prof. D. M. Newitt (Imperial College of Science and Technology, University of London).

The paper discusses the scope and nature of the research which can appropriately be undertaken in a university department of chemical engineering. Although the facilities available will usually impose limitations on the scale of the experimental work, the results, if properly presented, can constitute a valuable contribution to chemical engineering practice. In particular, the use of models based upon data obtained from large-scale plant affords the student an opportunity of becoming acquainted with industrial operations and processes, and of developing procedures for dealing with the large number of variables which are involved therein. The importance of dimensional analyses and the use of statistical methods is emphasised.

Discussion

Mr. H. W. Cremer (past president, Institution of Chemical Engineers), opening the discussion, said that for over 40 years his professional life had been devoted to chemical engineering, first as university teacher, and later in the practice of that applied science in the outer world. He had never doubted for one instant that a human being could be produced who could be appropriately designated a chemical engineer and could work extremely effectively in a variety of ways and in a variety of spheres, by no means excluding research, in the widest meaning of the term.

One had heard that the hybrid being, the chemical engineer, was likely to be a ' jack of all trades and master of none.' From personal experience Mr. Cremer did not believe that. In his opinion a man's latent ability as an applied scientist need not be in any way diminished by his particular type of training, provided that that training was soundly based. In an age when specialisation was increasing so rapidly, chemical engineering seemed to him to provide a most admirable opportunity for a truly cultural as well as a liberal education. It was uninhibited by the artificial boundaries of any particular science; it embraced and integrated a number of sciences, and he did not think its exponents were any less significant in the fields of research on that account. Chemical engineering was surely a part of the process of natural evolution in applied sciences. If chemical engineering were a compromise he was glad that it should be so—and the conference had been reminded that compromise was a major article of faith in this country.

It was important to recognise that in the conduct of research into problems of plant design there were two distinct approaches. On the one hand we had what might be called the synthetic approach, based upon an endeavour to establish by physical measurements the influence of factors entering into the problem; on the other hand, what was equally required was the analytical approach, in which accumulated physical knowledge was applied to existing plant to assess the relative importance of the

variables and to ascertain why trial and error had resulted in satisfactory operation. The practising chemical engineer knew by experience that if he calculated the leading dimensions of a plant from available physical data, the answer was very often wrong; but he did not know why it was wrong. It was therefore suggested that, although it was essential to encourage by all means investigation on synthetic lines, it was also necessary to follow the analytical approach. The attempt should be made to build the bridge from both ends. It was highly desirable that the closest possible interchange of opinion should be maintained between academic research and research in industry.

In Mr. Cremer's opinion the quality of the courses for the higher degrees in chemical engineering was no whit less than that in the pure sciences. The students were carefully selected; could it be doubted that their calibre was as high as in the pure sciences?

Dr. F. A. Freeth, emphasising the educational value of failures, submitted with great deference that it was a good thing to put young men of the right quality on to something desperate; everybody knew that that kind of thing brought out the best in a good man.

Dr. C. Clayton, commenting on the question of carrying university research to the stage of actual production, said he believed the universities should concentrate on basic and fundamental work. *Ad hoc* work should be done by industry or technical colleges; it should not be done by the universities. He agreed with the view that industrial firms themselves should analyse their problems and offer those of a basic character to the various university schools. He was against sponsored work on the American plan, where there were university research institutes; it had nothing to do with university work and should be kept separate. But he was in favour of sponsored research in the proper place, and he felt that we lacked sufficient sponsored research establishments here.

Dr. S. R. Tailby spoke of a scheme whereby a number of part-time research students were working for the internal Ph.D. degree of London University, at Battersea Polytechnic.

Mr. H. K. Suttle (Loughborough College of Technology) made the point that design was possible in an undergraduate course. It avoided the mental indigestion which seemed to result from continual lectures and bookishness, it gave the students the opportunity to express themselves, and inculcated the great importance of time, for the work must be done within a certain time.

Mr. A. S. White recalled that in the United States last year he had visited research stations at which there were people from many countries, and he had asked where were the Americans. The reply was that they could not get the Americans to do postgraduate work, for they could get good jobs when they obtained their degrees. Fortunately that was not the state of affairs in this country; but there was no doubt at all that industry would save a lot of time in training men if it would take them after postgraduate courses and not with first degrees; it would get better men and could train them in half the time. Some firms encouraged postgraduate research with quite adequate research grants.

The chairman, summing up, said it had emerged most clearly that with the rapid development of chemical engineering there was a most urgent need for more research. It was most heartening to hear about the research institute at Aachen, which had the joint support of industry and Government and the technical high school, because that seemed to him to be just the line on which it was so important that we should try to get the necessary financial support. In Britain it simply meant implementing the Cremer report. The final session of the conference would provide important backing for those who were fighting that particular battle.

In view of the urgency of the problems, it did seem that the field was ideal for European co-operation. We were all doing chemical engineering research, and he could not help feeling that if we had closer co-operation, even to the extent of certain delimitations of the field to certain countries, it would lead to ecomony of effort and of cost.

SUMMING UP

(Extract from *Sir Harold Hartley's* remarks)

What has become abundantly clear to me as the days progressed is that with one partial exception, of which I will speak later, there is a general agreement among the European countries represented here as to the conception of chemical engineering as a fourth primary technology which now takes its place alongside the other professions of civil, mechanical and electrical engineering. And I know that that view is shared by all the countries of the British Commonwealth.

The second result is to show that there is a large unsatisfied demand for chemical engineers and consequently a need to expand and multiply the schools of engineering in each country.

Now our deliberations have been greatly helped by the presence of some of the outstanding industrialists in this field who spoke in no uncertain way of their keen appreciation of the part played by chemical engineers in their team of specialists. Their presence was a great encouragement.

Now I come to the partial exception. Let me begin by expressing our admiration and our indebtedness to Germany for what she has contributed in the field which we like to call chemical engineering. Let me remind you of what the world owes to Adolf Baeyer and Emil Fischer and their pupils and to the Haber process, of those great pioneer developments of the synthetic industry in Germany round about 1900. I shall never forget the impression made on me by the imaginative chemical engineering of the Haber plant at Ludwigshafen when I first saw it. Now our German friends, for good reasons from their experience, have chosen rather a different approach to us. Let me say at once that we admire the skill of their Verfahrens Ingenieure which is seen to such advantage in the mechanical design of their plants.

We could do with more of that same breed in other countries, particularly in the field of plant manufacture. Their Verfahrens Ingenieure represent one band in Sir Christopher Hinton's spectrum or one arm of Prof. Donald's distribution curve. I must say that I was greatly comforted by what Prof. Schoenemann said of the need to supplement the classical chemist by the chemical technologist and how unfortunate it would be if the need for process engineers were to hinder the technological education of a number of chemists. Thereby he is building a bridge between our different approaches. Chemical engineering is still a very young profession, it is dynamic and it is in the stage of rapid evolution. So it is no wonder that there are different patterns and it is all to the good that it should develop on independent lines in different countries and universities. It is its adaptability and its flexibility that are its great strength. As Mr. White said, its ubiquity is its most marked characteristic. Its techniques are invading almost every industry and the hope of satisfying the world's growing demands depends more and more on chemical engineering, call it by what name you will.

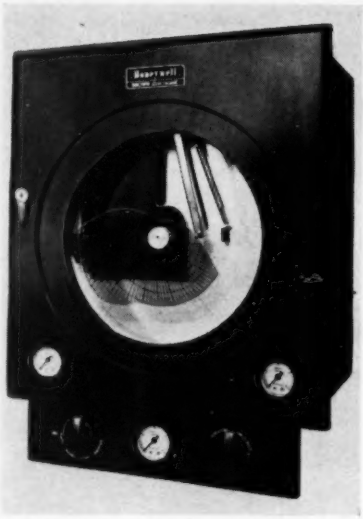
Plant and Equipment

Cam-operated programme controller

Honeywell-Brown Ltd. announce the addition of an *ElectroniK* circular chart cam-operated programme controller to their range of industrial instrumentation. The instrument utilises a transparent plastic cam, the contour of which is shaped to the desired time-temperature pattern. The cam rotates, and a cam roller with a follower arm continuously transmits the contour of the cam to the instrument control set point.

The makers claim that there is practically no limit to the time-temperature programmes which may be accomplished—and reproduced again and again—by the use of this instrument. For example, wherever material is heated (or cooled) at a fixed rate, held at some temperature for a certain period, then again cooled (or heated) at a controlled rate, the programme controller ensures uniform reproduction of the operation. Variables such as strain, weight, speed, etc., can be similarly programmed.

The typical process applications of these controllers include annealing, ceramic firing, controlled condition testing, drying, heat treating, plastic polymerisation, research, retort cooking and vulcanising.



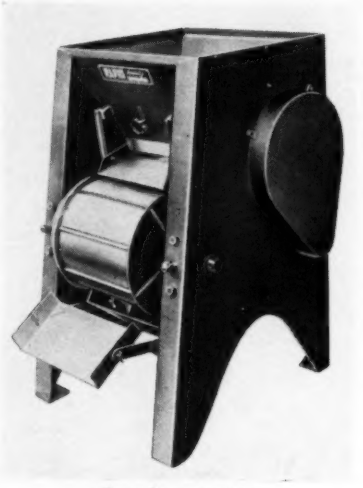
Programme controller with circular chart.

Direct reading pH meter

A new direct-reading *p*H meter, model 23A, has recently been announced by Electronic Instruments Ltd. This instrument is a development of the model 23 *p*H meter, which was originally introduced in 1947 and which, it is claimed, was the first direct-reading *p*H meter to become commercially established in Britain. The direct-reading instrument can be used by unskilled personnel as, once the instrument is standardised, it is only necessary to dip the electrode system into the solution being measured and to note the *p*H reading on the scale. In the same way, changes in *p*H may be continuously recorded without manual intervention by the operator.

The model 23A retains all the features of the earlier model, but there are two important improvements. Automatic temperature compensation has now been perfected so as to make the *p*H readings independent of changes in temperature of the solution being measured; this makes it no longer necessary to standardise the electrodes at the working temperature, and to apply corrections to the *p*H readings if the temperature limits are exceeded. The second improvement is the provision of a higher output current (100 microamps per *p*H unit) for operating recording or control instruments, and also a new electro-pneumatic converter for direct connection to air-operated instruments.

According to the makers, the model 23A will maintain a zero stability of 0.02 *p*H almost indefinitely, despite any normal variations in mains voltage or frequency.



Swarf separator.

Swarf separator

The *Rapid*-type J.Y.P. non-electric swarf separator is a motorised, self-contained machine with push-button control. The makers state that it incorporates features of design which provide uniform feed, correct presentation of the material to the magnet, agitation of collected iron for freeing non-ferrous material and automatic discharge of extracted iron—all essential features in continuous, high-degree separation.

The magnet unit is of the high-intensity pattern incorporating *Alcomax* 2 magnets. It is claimed that the permanent magnet unit, unaffected by power cuts and failure, requires no electrical wiring and eliminates maintenance and running costs.

The equipment includes a large-capacity built-in hopper with feed regulator, a jig shaker feeder, a diverting chute and a totally enclosed roller chain drive. A range of sizes are available having capacities from 20 to 80 cwt. per 9-hr. day.

The swarf separator is supplied by Rapid Magnetic Machines Ltd., who state that its function is similar to that of the company's 'J' model, but special attention has been paid to its construction and assembly, enabling it to be marketed at a lower price than the normal equipment.

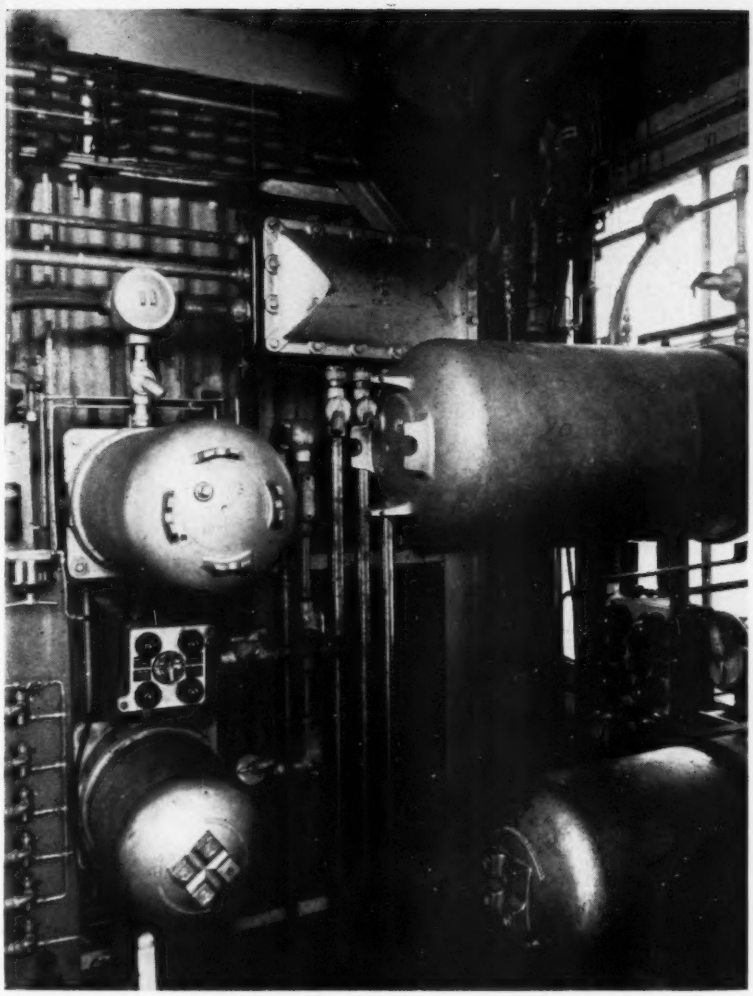
Centrifugal acid pump

To meet the demand for a satisfactory centrifugal pump capable of utilising stoneware in the chemical and food industries the Pulsometer Engineering Co. Ltd. have joined forces with Doulton & Co. Ltd. A stoneware pump is now made in three sizes, covering quantities from 1 to 450 gal. min. and heads up to 140 ft. It is specially designed to meet the limitations of stoneware as a material of construction.

The hood carrying the pump forms a rigid support both for the pump itself and the two bearings, and the shaft is of large diameter, which is stated to ensure freedom from vibration and distortion under working conditions. All interior parts are made in Doulton acid-proof stoneware, no other material coming into contact with the liquid being pumped.

The type of stoneware used for the impeller is a special grade of corundum ware which, the makers claim, has an exceptionally low degree of porosity, a smooth even finish and a high tensile strength.

They point out that corundum is much harder than ordinary acid-proof



Infra-red analysers in American Cyanamid Co.'s new petro-chemicals plant at Fortier in the U.S.A. Each analyser serves a bank of four burners and each monitors acetylene and methane in the product stream from the burners.

stoneware and is completely resistant to all acids except hydrofluoric, to most alkalis and to all food and chemical preparations for human consumption.

The impeller of the pump is of the single-inlet, shrouded type, made in corundum stoneware. The boss of the impeller extends right through the stuffing box so as to protect the spindle, whilst special design facings are provided to reduce the pressure on the packing to a minimum.

Additional details include a water thrower and dust cap of the labyrinth type to prevent acid liquid entering the bearing from the gland, whilst each bearing also has grease nipples and the shaft between is completely protected against any accidental contact with the acid.

Driving can be carried out in any convenient manner, either by direct electric motor drive with flexible coupling, by overhung flat or grooved pulley, or by overhung fast and loose pulley, in this case the latter running in a ball bearing. Direction of rotation also is anti-clockwise when looking towards the driven end.

New diaphragm pump

Research into the problem of providing small quantities of compressed air at low pressures completely free from oil vapour and other impurities has led to the introduction of two versions of a new diaphragm-type compressor. Both provide a free air delivery of 2½ cu.ft. min. at 35 p.s.i., one having its own electric motor flange-mounted on the compressor body and the other being arranged for belt drive from a separate power source. The equipment is designed for such duties as food processing, pumping consumable liquids like milk, beer, vinegar and soft drinks, pressurising instruments and for many special processes in medical or industrial laboratories.

The conventional cylinder and piston are replaced by a multi-ply diaphragm, thus obviating any necessity for oil in the compression chamber. The connecting rod is an aluminium alloy casting, shaped at the top into a circular disc upon which the diaphragm is seated. At the top of the compression stroke, this disc conforms to the contour of the diaphragm which has its outer edge nipped between the main casting and the compressor head.

The plate holding the diaphragm in position on the disc houses the reed-type inlet valve—air thus being transferred through the diaphragm and its seating. The stainless-steel delivery valve of the same type is accommodated in the aluminium-alloy head sealing the compression space. This compression chamber is so designed as to help damp out pulsation.

The bottom end of the connecting rod is split to house a sealed ball race constituting the big end bearing. This, like the bearings of the hollow overhung crankshaft, is grease packed so that no servicing should be necessary between major overhauls.

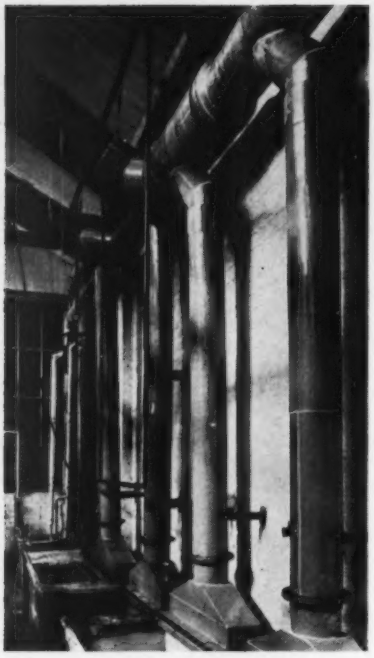
The two models are supplied by the Hymatic Engineering Co. Ltd.

Infra-red process control

A new $50 million petro-chemical plant of American Cyanamid Co., at Fortier, Louisiana, is successfully using continuous infra-red analysers to control the purity and output of its process stream according to the Perkin-Elmer Corporation, manufacturers of the instruments. It is stated that this is the first time such continuous analytical controls have been designed into the process stream of a chemical plant of this size. The instruments enable plant operators to know exactly, at any moment, what the composition of the product stream is.

Continuous infra-red analysers operate on the same principle as infra-red spectrometers used in chemical laboratories. Briefly, any organic material when irradiated with infra-red energy will absorb certain wavelengths of this energy that are charactertistic of it alone. An infra-red spectrometer plots this absorption versus wavelength and the resulting graph, known as a spectrum, is a positive identification of the particular material.

The principle product of American



RIGID PVC IN THE ELECTRO-PLATING INDUSTRY

Rigid Geon PVC was used by Plastic Constructions Ltd. in making these exhaust ducts and hoods for acid fume extraction during plating operations. This material, supplied by British Geon Ltd., is readily shaped after being softened by heat, and sheets of this material are quite easily built up into large installations by means of hot gas welding.

Cyanamid's Fortier plant, built by the Chemical Construction Corporation, is acrylonitrile, made by reacting hydrogen cyanide with acetylene. The acetylene unit, a vital part of the operation, was developed by Badische Anilin Soda-Fabrik in Germany and the Chemical Construction Corp. holds the exclusive U.S. rights for the process. In the process, natural gas and oxygen are reacted in burners of unique design. Principal reaction products are carbon dioxide, carbon monoxide, hydrogen and acetylene.

Oxygen for the process is supplied from an air separation plant which also produces nitrogen. Part of this nitrogen, plus hydrogen from the acetylene unit are reacted to make ammonia as a by-product.

Several *Tri-non* analysers have been installed at Fortier. One pair is mounted near each of the two groups of four burners. One analyser in each pair determines methane concentration and the other, acetylene. An automatic sampling system successively admits a small portion of gas from each of the burners into the analysers and the results are recorded on a chart for each analyser in a control room two floors below. Sample cycling time is 8 min., for four burners.

From the burners, the product stream passes through filters for soot removal and then into compressors. It is important to know exact acetylene concentration at this point since pure acetylene cannot be compressed beyond a certain pressure without danger of a violent explosion.

At the next step, the acetylene absorber, another analyser samples the off-gas. This gas goes to the ammonia plant and acetylene concentration must be less than 0.3%. Two other analysers monitor efficiency of carbon dioxide removal in the purification tower. One determines carbon dioxide concentration half-way up the tower and the other measures carbon dioxide in the acetylene product, where it is held to less than a few tenths of 1%.

Additional *Tri-non* analysers are installed in the ammonia unit of the Fortier plant. One of their most important tasks is to check on the concentration of oxygen-containing compounds in the feed streams to the ammonia reactor. One analyser checks on the efficiency of carbon dioxide removal in the caustic soda scrubbers. Here carbon dioxide level is held in the 5 p.p.m. range. The other analyser measures traces of carbon monoxide at the outlet of the caustic scrubbers.

It is stated that these analysers not only respond faster, but require far less attention than other analytical methods.

Removing and replacing heat-exchanger bundles

A new hydraulic handling device for removing and replacing heat-exchanger bundle tubes is claimed to reduce the usual safety hazards presented by conventional equipment and can be operated by only two men to push a bundle 8 ft. in less than 25 min. According to the suppliers, the Fabricated Products Division of the M. W. Kellogg Co., U.S.A., even the largest bundles will not stick when moved rapidly with the 12,000-lb. force which can be exerted by the device. Since the ejector is attached directly to the exchanger shell, no temporary steel structures are required to withstand the thrust. None of the removal force is transferred to the exchanger supports.

The *Hydro-ejector*, as it is called, is available as a complete packaged unit, including the pump, hose, adjustable yoke, ram, tie rods, cable and all other necessary equipment.

NEW PRODUCTS IN BRIEF

Long-life swilling basket, made from perforated steel. Makers state it will withstand constant immersion in strong chemical fluids such as hydrochloric, phosphoric and sulphuric acids, and is specially valuable for use in the phosphate and oxide processes. Depth of basket 10 in., diameter $7\frac{5}{8}$ in., with 10-in. high handle. (Tool Treatments (Chemicals) Ltd.)

*

Micro sampling electrode system, designed for determining the *p*H of very small quantities of liquid in routine analysis. There are two vessels, one containing a reference electrode and the other a glass electrode. The sample is introduced through a funnel in the side of the vessel containing the glass electrode and connection is made through a porous plug and KCl liquid junction to the reference electrode. A tap enables the vessel to be emptied and flushed after the determination has been made. (Roles & Parker Ltd.)

*

Aluminium soldering tool which cleans and tins at the same time and, as no flux is used, no precaution in heat control is necessary. To cope with the high heat conductivity of aluminium without preheating, the tool is fitted with a high-rated heating element to bring the tool up to 500°C. (Belark Tool & Stamping Co. Ltd.)

*

Protection for equipment operating under extremely high temperature and corrosive service conditions is stated to be provided by *Kel-F* plastic dispersions, which may be applied by spraying, dipping or spreading to a broad variety of metallic and non-metallic surfaces.

Two major types are available commercially: a low-viscosity dispersion supplied at normal spray viscosity and a high viscosity dispersion for spread, flow and dip coatings. (M. W. Kellogg Co., U.S.A.)

*

New design of Finch cold-cathode-type electron diffraction camera, incorporating the latest valves, vacuum unions, fittings and pumping equipment. Cameras of this type are used for investigation work connected with thin films, crystal structures and monomolecular layers. (W. Edwards & Co. (London) Ltd.)

FOR DETAILS OF THE PLANT AND PRODUCTS DESCRIBED, PLEASE USE THE COUPON ON PAGE 236

Personal Paragraphs

★ **Dr. E. G. Woodroofe** has been appointed head of the Research Division of Unilever in succession to **Dr. H. J. Channon,** who has resigned. The director of Unilever Ltd. and Unilever N.V. responsible for Research Division and Technical Division will be **Mr. J. A. Connel.**

★ **Mr. Alan C. H. Cairns,** chemical sales director of Joseph Crosfield & Sons Ltd., is on a seven weeks' tour of the United States and Canada until July 13. He is visiting, amongst other towns, Philadelphia, Pittsburgh, St. Louis, Chicago, Milwaukee, Toronto, Montreal and Baltimore.

★ **Mr. W. Lindsay Burns,** managing director of the Balfour Group of companies, has recently returned from a six weeks' business trip to the United States and Canada. He discussed various projects with their associates, the Pfaudler Co. of Rochester, U.S.A. and with Dominion, Scott, Barron Ltd. of Toronto, a subsidiary company working on the design and manufacture in Canada of the plant of George Scott & Son (London) Ltd. and W. S. Barron & Son Ltd. of Gloucester.

★ **Mr. Lindsay Burns, Jnr.,** and **Mr. I. M. O. Hutchison** have been appointed joint assistant managing directors of the Balfour Group.

★ **Mr. Edward A. O'Neal, Jnr.,** has been elected to the board of Monsanto Chemical Co., U.S.A. He has been appointed to the executive offices of the president as a functional vice-president. His duties will include the integration of overseas activities of Monsanto with activities of the rest of the company. Mr. O'Neal will continue as chairman of Monsanto Chemicals Ltd., which office he has held since 1949.

Mr. I. M. O. Hutchison.

★ **Mr. W. Hamilton** has become sales manager of the Engineering Division of Sheepbridge Equipment Ltd., a subsidiary of Sheepbridge Engineering Ltd. **Mr. W. J. Rickard** has been appointed Midlands area engineer for Twiflex Couplings Ltd., another Sheepbridge company.

★ **Mr. M. Seligman,** managing director, and **Mr. J. F. B. Jackson,** deputy managing director of A.P.V.-Paramount Ltd., recently returned from a visit to the leading Swiss stainless steel foundries.

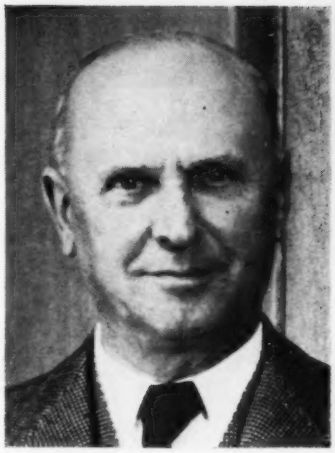
Mr. A. C. H. Cairns.

★ **Mr. H. A. Collinson** has been appointed chairman of the British Plastics Federation's main technical committee which co-ordinates the work of the Federation's technical committees.

★ **Dr. Horace W. Clarke** has been elected president of the Aluminium Development Association. He is chairman and managing director of James Booth & Co. Ltd.

★ **Prof. M. Stacey** and **Sir Alexander Todd** have been elected vice-presidents of the Chemical Society and **Prof. F. Bergel** has been elected honorary secretary.

★ **Dr. Z. E. Jolles** has recently been appointed to the board of Leda Chemicals Ltd. as research director.



Mr. W. Lindsay Burns.

★ **Dr. W. Idris Jones,** C.B.E., presided at the Annual General Meeting of The Institute of Fuel, held in London recently. **Mr. R. H. Gummer** will take office as president, on established procedure, in the autumn.

Mr. W. N. C. Clinch and **Dr. W. A. Macfarlane** now become vice-presidents, and the following were declared elected members of Council: **Mr. D. T. Barritt, Mr. E. C. Evans, Dr. J. G. King,** O.B.E., **Dr. H. L. Riley** and **Sir Ernest Smith,** C.B.E.

★ At Styrene Products Ltd., the plastics manufacturing company owned by Petrochemicals Ltd. and Erinoid Ltd., there have been some board changes following the acquisition of Petrochemicals by Shell Chemicals. **Mr. Godfrey H. Owtram, Mr. E. J. Barnsley** and **Sir Robert Robinson,** all of whom recently resigned from the Petrochemicals board, have also resigned from the Styrene Products board.

They have been succeeded by **Mr. A. D. Koeleman, Mr. W. F. Mitchell** and **Mr. L. H. Williams,** all of Shell. The Erinoid directors, **Mr. H. E. Harden** and **Mr. J. Harvey,** remain on the Styrene Products board and **Mr. P. C. Chaumeton** continues as managing director.

★ **Mr. J. P. A. Meldrum,** O.B.E., and **Mr. R. H. S. Turner** have been appointed directors of Metropolitan-Vickers Electrical Co. Ltd.

★ **Mr. D. J. I. Davies** has resigned his position as sales manager with Styrene Co-Polymers Ltd., in order to take up an appointment with Hygrotherm Engineering Ltd. in charge of their new northern area office in Manchester.

ALUMINIUM CENTENARY

THE evolution of aluminium as a commercial metal owes a good deal to the persistent efforts of chemists and chemical engineers. It is an interesting reflection that, today, the metal is repaying that debt in various ways, for instance, by making itself useful in chemical and food processing plant.

It is just 100 years ago since the French scientist, Ste. Claire Deville, exhibited a bar of aluminium ('silver from clay') at the Paris Exhibition. In London this month an exhibition is being staged by the Aluminium Development Association which will celebrate the centenary of aluminium as a commercial metal and show the progress that has been made in producing aluminium and putting it to use.

CHEMICAL & PROCESS ENGINEERING *also salutes the achievements of the aluminium industry and to mark its centenary we present an article in which some of the early struggles to produce aluminium economically are recorded. Our contributor recalls not only some interesting facts about Deville's experiments, but also an important phase of aluminium history which is often passed over by the textbooks and which has a special interest for the chemical industry because of its link with sodium-making history.*

Birth of the Aluminium and Sodium Industries in France and the Midlands

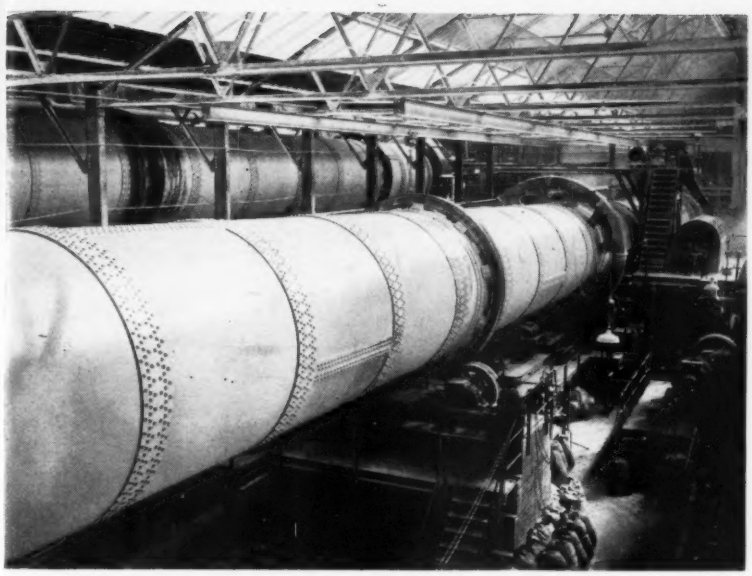
By M. Schofield, M.A., B.SC., F.R.I.C.

ALTHOUGH Deville's process for sodium displacement of aluminium marked the birth of the aluminium industry and of an intensive drive to manufacture sodium metal economically, this dual process was used even more successfully at Oldbury, Birmingham. The growth of Oldbury as a centre of the phosphorus industry has now been fully covered, thanks to R. E. Threlfall's 'One Hundred Years of Phosphorus Making.' Oldbury 100 years ago was also the scene of a great struggle in soda making by a chemical off-shoot of the Chance organisation at Smethwick. This effort to work the Leblanc process based on Worcestershire salt formed a chapter equally as vigorous as the battle of the alkali makers in the north. There was the same trouble with HCl fumes before Gossage's absorption system; and the same compensations to be paid to neighbouring property owners. Not only could Oldbury provide the soda for Castner's sodium making—in that period when young Hamilton Castner was made a director of 'the largest aluminium works in the world' (that of James Webster at Oldbury in the 1880s)—but the vitriol for huge quantities of hydrochloric acid required to produce aluminium chloride was also forthcoming in that same area where Roebuck gave the world the lead-chamber process for vitriol.

Soda, sodium, and hence aluminium furnish an absorbing study which Deville begun, and which Webster continued in a manner and on such a scale that it is surprising to find our histories of the chemical industry, and particularly those purporting to cover the early development of aluminium, failing to give credit to a vital phase. Since Ste. Claire Deville, backed financially by Napoleon III, began this commercial production of sodium and aluminium, the French period, opening in 1854, may be considered first, though bearing in mind that Webster is believed to have been studying the idea of aluminium making even as early as 1851.

Louis Napoleon, though he himself had failed to become a chemist while instructed by pharmacist Acar in the fortress of Ham, was ever ready to champion the cause of science. He gave support to Pasteur, carried on the Napoleonic tradition in sponsoring beet-sugar manufacture and called on Deville to produce aluminium, cheaply if possible, for making lighter equipment for his armies. The first aluminium went to the making of a baby's rattle for his son, the Prince Imperial; the first aluminium dishes, spoons and forks were made for the Emperor by Deville in 1855, these attracting by their lightness and the then novel appearance of 'silver from clay.' On the academic side, the first aluminium prepared by sodium displacement, instead of Wöhler's use of potassium, was shown to the Academy of Sciences, a body which advanced Deville a small sum for research.

But what mattered in the first effort towards industrial aluminium was Napoleon's financial backing for the Javel works. With Debray as collaborator, Deville studied the more economic manufacture of sodium metal undertaken by the Rousseau brothers. He appreciated how sodium, unlike Wöhler's potassium, could be melted and cast industrially. Using iron mercury flasks as first reaction vessels in his furnace, Deville went on to use cylindrical retorts over a metre in length, this after most mercury flasks had been shipped to the gold fields of Australia and California. With a charge of 717 parts soda ash, 175 parts wood charcoal and 108 parts calcium carbonate, sodium production began, the use of Charleroi coal as alternative



MODERN ALUMINA PRODUCTION

Modern electrolytic methods of producing aluminium are in contrast with the clumsy and uneconomical methods of the early pioneers. However, the first stage in the production of aluminium is the extraction of alumina by the Bayer process, which is still operated essentially in the same way as 60 years ago. The fine crystals of hydrate of alumina that are obtained, are calcined in large rotary kilns which drive off the water and convert the hydrate into the oxide, alumina.

The photograph shows the rotary calciners at the Burntisland (Scotland) factory of the British Aluminium Co. Ltd. They are some 200 ft. long and 9 ft. in diameter. In these oil-fired kilns the hydrate of alumina crystals are heated to about 1,300°C., driving off the moisture and converting the hydrate into the oxide, alumina.

being intended to give hydrogen and sweep the sodium vapour into the condensers before it reacted with carbon monoxide.

Deville's cheap aluminium quest

It is interesting to follow Deville's significant contributions to this commercial adoption of sodium and aluminium metals and to note his careful purifying of aluminium chloride from its crude form rather than preparing pure alumina first as Webster did. At Javel the crude chloride was distilled into a cylinder containing up to 80 kg. of iron nails heated to redness. The iron not only removed ferric chloride by conversion to ferrous chloride not volatile at a dull red heat, but it also reacted with the free hydrogen chloride from hydrolysis of $AlCl_3$ and with small amounts of sulphur compounds.

The purified $AlCl_3$ was charged into large cast-iron boats each containing 500 g. of sodium, and a brisk reaction ensued between the chloride and the sodium within the cylindrical iron plant. The double chloride of sodium and aluminium, corresponding to the cryolite which was used later, volatilised into adjacent boats where sodium reduced the $AlCl_3$ to aluminium metal formed as globules, which were dried and cast. The aluminium first shown at the Paris exhibition contained copper, for Deville had then used copper boats in place of iron and had unwittingly sent samples of alloy to the exhibition.

Reduction with sodium vapour was tried out by Deville and found unsuccessful on a large scale. Very early in the Deville contributions came the first efforts to produce aluminium by electrolytic means. Bunsen's classic preparation of magnesium and alkaline earth metals had just been published, a method using molten salt baths as electrolyte and pieces of clavichord wire as hooked electrode. Hence Deville provided the analogous study of aluminium preparation, using the double chloride as electrolyte at first and obtaining a little aluminium at the bottom of the crucible, this being rolled and sent to an Academy meeting. In this initial effort Deville's carbon electrodes disintegrated, apart from other factors vitiating success. Yet how near he came to anticipating the Hall-Héroult process when he used cryolite and sodium chloride as an electrolytic bath for preparing some aluminium, and even went on to discuss artificial cryolite production. In 1855 Dr. Percy in London had supervised the preparation of a little aluminium by the action of sodium on fused cryolite, a sample of this metal being shown by Faraday at the Royal Institution in that year. But Deville was prejudiced against the use of fluoride baths for either the sodium-reduction or the electrolytic methods, since the aluminium contained impurities.

After studying the properties of his aluminium produced by the sodium method, Deville anticipated several applications in industry. He foresaw its use in place of silver in mirrors, as a light metal for telescope mountings and in instruments such as sextants. Later we hear of a Philadelphia instrument-maker purchasing European aluminium for such uses. Most noteworthy was Deville's definite views on aluminium being harmless in household culinary utensils, a point fully borne out by considerable research since his day. It is surprising to find in print today such a booklet as 'Aluminium: A Menace to Health,' by Mark Clement, a work damning aluminium as ' a slow-acting poisonous metal ' and one ignoring the consumption of considerable quantities of colloidal $Al(OH)_3$ by many thousands of duodenal patients!

Aluminium production pioneers

After the initial production at Javel there followed a number of aluminium manufacturing operations in France and in Britain. At Amfreville-la-Mi-Voie, near Rouen, the Tissier brothers, chemists who were in the laboratory of the Javel works, began production by Deville's method. Later the Rouen works changed hands and the Tissier brothers broke away from the Deville interests. Deville was bitter in his charging the Tissiers with taking drawings of furnaces and details of his process, apart from publishing a book in which Deville's work was disparaged. In this further activity the Tissiers used the Percy and Rose modification, in which pulverised cryolite, sodium chloride and metallic sodium were the reactants in large refractory crucibles.

Meanwhile, we hear of Deville

carrying on first at Glacière, in a small plant owned by the Rousseau brothers, chemical manufacturers, and then at Nanterre—the latter move being forced on him since the discharge of chlorine-containing fumes was not received too well in the Glacière suburb of Paris.

In Britain, the year 1859 saw a small production in the factory of F. W. Gerhard at Battersea, some of the aluminium being shown at a Society of Arts exhibition in 1860. In 1863 the Bell factory was opened on Tyneside, this concern at a later stage using the Netto process, which resembled the Rose method in reducing a mixture of fused cryolite and sodium chloride with metallic sodium. Netto, of Dresden, was an active worker in the sodium-aluminium field, with later patents for sodium production by reacting fused caustic soda with red-hot charcoal in lumps large enough to permit the escape of sodium vapours. At the British Association meeting in 1889 the Netto process as worked at Wallsend-on-Tyne was described. In this effort by the Alliance Aluminium Co., sodium in 5-lb. charges was forced by a ' dipper ' under the surface of a fused bath of cryolite and sodium chloride within a reverberatory furnace, white fumes of sodium fluoride evolved making the process hazardous.

All these efforts were on a moderate scale compared with the Castner-Webster production by the Aluminium Crown Metal Co., first of Hollywood, Birmingham, and then at Oldbury. It seemed appropriate that Castner should stage his intensive efforts in sodium production in an area which had such a record in alkali and soap making. It was the area in which James Keir, F.R.S., began making soap and alkali; and in which R. S. Hudson struggled to perfect Hudson's soap in a back room of his West Bromwich shop before opening a factory in which he increased production in a novel way—by getting his girl workers to sing with a quicker tempo in place of the doleful hymn they sang while at work.

The chemically minded Chance family established an alkali and vitriol factory at Oldbury from 1837 onwards, erecting large vitriol chambers of up to 120 ft. in length as if to commemorate that Roebuck introduced lead chambers to vitriol making while he was in Birmingham. Apart from considerable amounts of hydrochloric acid rendered available for the production of aluminium chloride, there was another link with Webster's growing industry in the sale by the Chance brothers in 1887 of land for the Aluminium Co.'s new works.

Successful production of aluminium and sodium in Britain

James F. Webster seems to have been a farmer in his early years, yet he began to take an interest in the new metal aluminium many years before he dominated the English market, became a serious rival to the French interests and eventually was able to produce aluminium at the rate of 100,000 lb. annually in days when the United States could turn out a few hundred pounds. He owed his success to the sodium making of Hamilton Castner, a graduate of the Columbia School of Mines who had first experimented with sodium manufacture in a small building near Waterloo Bridge. Yet before Castner joined hands in this remarkable Midlands' industry, Webster was engaged in his first successful aluminium-making activities. He designed buildings and equipment for his Hollywood venture, spending up to £3,000 to secure his patent rights at home and abroad. He seems to have advanced further than the stage reached in French aluminium manufacture, for a French syndicate was reported as offering him £25,000 for use of his patent rights. His ' most modern ' Hollywood plant was erected in 1878-82, with sheet-rolling and wire-drawing mills included. By 1881, day and night working had become necessary to cope with orders.

Apart from Castner's improved sodium process, which brought the climax of 1889, Webster's success was greatly due to his method of purifying raw materials. Instead of purifying crude aluminium chloride, as in Deville's method, Webster purified the alumina used for this salt. He heated alum and pitch in a calcining furnace, treated the residue with air and steam in vertical retorts, extracted potash and recovered sulphur by leaching the mass, presumably removing iron as Fe_2O_3 from the potassium aluminate.

In his full-scale production in 1889 he used 12 regenerative furnaces for the conversion of his purified alumina to the double chloride. This operation consisted in heating the alumina with salt and carbon milled to cylindrical pieces and chlorinating the mixture after four hours' calcining. The chlorine section of the full-scale plant was a striking example of the use of Weldon's process introduced some years before Webster's venture. In the aluminium production department large sodium blocks were cut to thin slices in ' a machine similar to a tobacco-cutting machine,' the metal being mixed with the double chloride of sodium and aluminium in rotary mixers. Cars on a tramway moved the mixture to hoppers above the furnace hearths. After a 2-hr. reaction each unit produced 120 lb. of aluminium from 600 lb. of cryolite, 1,200 lb. of double chloride and 350 lb. of sodium metal. The aluminium was of 99.2% purity, far superior to Deville's aluminium with its 2.7% iron and 0.3% silicon. For 1 ton of aluminium Webster used 6,300 lb. of sodium obtained from 44,000 lb. of caustic soda, 7,000 lb. of iron carbide and 75 tons of coal.

Castner and sodium manufacture

Webster's great success of the 1880s was soon to be ended with the birth of the Hall-Héroult process, the history of which has been fully covered in textbooks. About 1890, a pilot plant for producing 300 lb./day of aluminium was in operation at Patricroft, near Manchester, a place also noted for early production of electrolytic magnesium. In 1896 the British Aluminium Co. started producing aluminium by the Héroult process at Foyers to complete the change-over in method of producing the metal.

Yet Castner's cheap sodium, produced at 1s. a pound instead of the original price of 14s., formed a classic chapter ignored by textbooks which confine attention to Castner's later sodium manufacturing method in the Cheshire-Lancashire field. In the Midland industry where Gossage also had his first success based on Worcestershire salt, Castner improved his sodium manufacturing technique, with benefit to other industries dependent on sodium metal. Thus, when the main outlet in Webster's aluminium was cancelled, Castner applied his cheaper sodium to the manufacture of sodium cyanide from the molten metal, charcoal and ammonia.

Further, the history of sodium production by the reduction process and then by electrolytic means is not so simple as is commonly believed. The electrolysis method might well have begun in 1808 when Napoleon I provided Gay-Lussac and Thenard with an enormous electric battery built of barrels, lead troughs and siphons, all designed to prepare electrolytic sodium so that France should not be outdone by the Englishman, Davy, who had isolated sodium in this way. Yet before the huge apparatus could be got working, the two French chemists showed that reduction of molten caustic soda by iron was better.

Switching to 1945, one finds a patent (U.S. Pat. 2,391,728) granted to the Dow Chemical Co. for produc-

tion of sodium metal from sodium carbonate and charcoal at high temperature, the sodium vapour being condensed by rapid chilling in a lead alloy of 5 to 15% sodium. Part of this quenching liquid is withdrawn to a still for sodium removal at 600°C.

Tracing the origin of Castner's sodium making in the Midlands, one first finds an announcement in the *New York World* for May 16, 1886, concerning ' Mr. H. Y. Castner, whose laboratory is at 218 West Twentieth Street, New York, who has the first patent ever granted on this subject in the United States and the only one taken out in the world since 1808. The metal is reduced and distilled in large iron crucibles, which are raised automatically through apertures in the bottom of the furnace, where they remain until the reduction is completed and the sodium distilled. Then the crucible is lowered, a new one containing a fresh charge is substituted, and raised into the furnace. Mr. Castner expects to produce it at 25 cents a pound, thus solving the problem of cheap aluminium, and with it magnesium, silicon and boron, all of which depend on sodium for their manufacture. Mr. Castner is well known in New York as a chemist of good standing. . . .' (The writer of this New York article would have been surprised to hear that Castner, despite his universally used electrolytic processes, was not destined to win a niche in the comprehensive American Dictionary of National Biography.)

In Deville's sodium process, lime was added to render the mass more refractory and porous, otherwise the alkali would separate from the lighter carbon. In Castner's method the heavier iron carbide remained below and in contact with the alkali. His first cast-iron pots used in the Midlands were 14 in. deep and 8 in. diameter at the top and worked at 1,000°C. Fine iron and tar were coked together, and this coke ground and used as reducing agent in the reaction (as given by Castner):

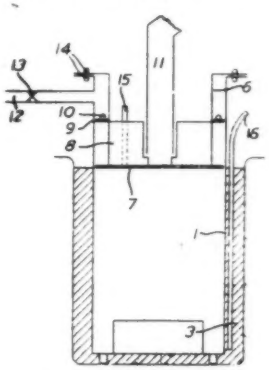
$$3NaOH + FeC_2 \rightarrow$$
$$3Na + Fe + CO + CO_2 + 3H$$

By 1888 the operation was carried out in ' egg-shaped ' vessels, 18-in. wide and 3-ft. high, the lower half of such vessels being Castner's crucible pattern while the top ' cover ' had an upright stem and a protruding hollow arm. Hydraulic lifts moved the crucibles after a 2-hr. distillation period, the residues being tipped while hot so that a freshly charged crucible was still hot on returning to the furnace. A total of 20 crucibles were worked continuously day and night, the sodium going into condensers 3-ft. long and thence being discharged into small pots.

British Patent Claims

Purifying calcium

A process for the purification of calcium, which contains alkali metal as an impurity, comprises distilling the impure calcium in the presence of an inert gas at an absolute pressure not greater than 2 mm. of mercury, condensing substantially pure calcium on



a condensing surface of iron or a ferrous alloy and condensing the alkali metal on a separate condensing surface, the two condensing surfaces being maintained at suitable temperatures by separate cooling means. The calcium condensate is then separated mechanically from an iron-containing layer.

The apparatus shown comprises stainless-steel vessel 1 supported in a fused salt bath 3. The still is connected through pipe 12 and valve 13 with a vacuum pump and a source of inert gas. The calcium condenser is formed by a plate 7 cooled by air introduced through pipe 11 and passing over the radial cooling fins 8. As the calcium deposit increases in thickness the flow of air is increased to maintain the correct temperature on the condensation surface. The impurity vapour, *e.g.* sodium, passes by the annular space around plate 7 and is condensed on the ring 9 which is cooled by flow of water in coil 10. Additional water cooling coils 14 are provided at the joint between vessel 1 and cover 6 and thermocouple sockets 15 and 16 indicate the temperatures at the calcium-condensing surface and in the still respectively.—698,861, *Minister of Supply*.

Agitating devices

Apparatus for producing high-frequency oscillations in liquids includes a container for the liquid having therein a flow-producing device for producing a flow of a portion of the liquid, a frequency-producing device adapted intermittently to interrupt the flow and divide it into a multiplicity of liquid impulses at high frequency and a waveform-controlling device for determining the waveform of the impulses prior to their impingement on to the mass of the liquid. The frequency-producing device is formed as a body of revolution so as to transmit the impulses radially therefrom, and the waveform-controlling device is shaped to conform to the contour of the frequency-producing device.

In one embodiment the flow-producing device is in the form of a number of blades 3 (Fig. 1), disposed about a central space and rotatable about a central axis 6, and the frequency-producing device is in the form of a hollow perforated cylinder 4 surrounding the blades. Exterior to the frequency-producing device is a waveform-controlling device, not shown.

In the arrangement of Fig. 5 there is shown in cross-section a flow-producing device rotatable about an

FIG. 1.

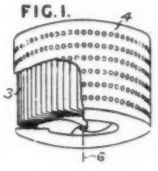
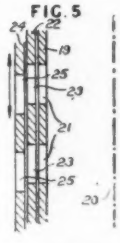


FIG. 5



axis 20, and having a cylindrical distributing device 19 with apertures 21 through which the accelerated liquid streams are directed. A cylinder 22 exteriorly of the cylinder 19 has frequency-producing apertures 23 and an outer cylinder 24 has waveform-controlling apertures 25. The cylinder 24 can be arranged for periodical vertical movement causing a regular variation of the effective aperture size, thereby continuously varying the waveform of the oscillations.—698,371, *K. F. R. Nekolny and F. Konig*.

World News

GREAT BRITAIN

New gas-making plants

New gas-making capacity to a total of 99 million cu.ft./day was completed and brought into operation during the nine months ending December 1954. This is stated by the Gas Council, who also reveal that this capacity was almost equally divided between carbonising and other gas-making plant. In the same period there was a net increase of 1,880 miles of mains.

The production of coal gas during the nine months increased by 1½% and the quantity of coal used by 1%, but water-gas productions increased by 21%, and the use of oil in water-gas by 27%. In the quarter October to December, 1954, the gas industry used nearly a million gallons of heavy oil in oil gasification plants and over a million gallons of heavy oil in water-gas plant.

During the nine-months period, crude tar production increased by 1½% and crude benzole production by 8½%.

Monsanto expansion

In his annual report for 1954 the chairman of Monsanto Chemicals Ltd., Mr. E. A. O'Neal, Jnr., stated that during the year the company carried out expansions in a number of its manufacturing plants. Products affected were polystyrene plastic, where capacity was increased; chemical additives for lubricating oils; chemicals for the rubber industry; chlorine and intermediates for detergents. Phthalic anhydride capacity is currently being extended and major process improvements in the synthetic phenol plant will increase both output and efficiency.

Conversion of the dodecyl benzene plant to the use of an olefine raw material, together with new engineering, has resulted in a major increase in capacity. Increased capacity has also been achieved in the plant manufacturing additives for the lubricating oil industry, where the company's research and engineering groups have perfected a continuous process for the manufacture of detergent additives.

Monsanto's facilities for the manufacture of rubber chemicals have been strengthened by the installation of versatile general-purpose plants designed to provide the greatest possible flexibility in the manufacture of both new and existing products. Further expansion is projected.

The completion of an interim plant from which experimental quantities of rubber-like resins made from styrene and butadiene have been made available was also referred to, as well as the company's intention to expand its present output of maleic anhydride for both home and export markets by building a plant to produce it from benzene.

In addition to these and other developments, the company has also embarked on a major project for the manufacture of cyclo-hexylamine, a raw material used in the production of many of its rubber chemicals.

B.C.P.M.A. officers elected

Mr. W. J. Hooton (S. H. Johnson & Co. Ltd.), the retiring chairman, was re-elected for a further year of office at the 35th annual general meeting of British Chemical Plant Manufacturers Association held in London on May 10.

The following were elected to the Council: Mr. P. D. Doulton (Matthew Hall & Co. Ltd.), Mr. H. W. Fender (Prodorite Ltd.), Mr. E. S. Franklin (Torrance & Sons Ltd.), Dr. M. Guter (Costain-John Brown Ltd.), Dr. R. Lessing (Hydronyl Syndicate Ltd.), Mr. G. W. Riley (George Scott & Son (London) Ltd.), Mr. R. W. Rutherford (Power-Gas Corporation Ltd.), Mr. P. W. Seligman (A.P.V. Co. Ltd.) and Mr. R. F. Stewart (Dorr-Oliver Co. Ltd.).

Mr. Fender, Mr. I. M. O. Hutchison (Henry Balfour & Co. Ltd.) and Mr. Rutherford were elected vice-chairmen by the Council and Mr. Seligman was elected honorary treasurer.

The annual report of the Association is referred to elsewhere in this issue.

Summer course in unit operations

A short vacation course, which will be held at Loughborough College of Technology from July 18 to 30, will take the form of lectures and related practical work on such unit operations as heat transfer and fluid flow, distillation, evaporation, absorption, filtration, drying and humidification.

In previous courses, heat transfer has been the main theme; the present course will allow the same specialisation on heat transfer, if required, as previous courses, but will also make possible the study in a more general way of some of the unit operations previously mentioned. Some degree of specialisation, however, will be possible in individual cases.

New president of the Institution of Chemical Engineers

Mr. John A. Oriel, C.B.E., of Shell Petroleum Co. Ltd., was elected president of the Institution of Chemical Engineers at the 33rd annual corporate meeting, held in London on April 26. The following elections were also made:

Vice-presidents: Dr. W. Idris Jones, Dr. N. E. Rambush, Mr. H. L. Roy and Mr. P. K. Standring.

Joint Hon. Secretaries: Prof. M. B Donald and Mr. F. E. Warner.

Hon. Treasurer: Mr. F. A. Greene.

Members of Council: Mr. H. D Anderson, Mr. W. E. Aylwin, Mr. C. G. Bacon, Mr. K. Fraser, Mr. R. C Odams and Mr. J. P. V. Woollam.

Continuing members of Council are: Dr. H. W. Ashton, Mr. E. Le Q Herbert, Dr. E. H. T. Hoblyn, M.B.E. Dr. J. S. Hunter, Dr. H. R. C. Prat and Mr. K. B. Ross.

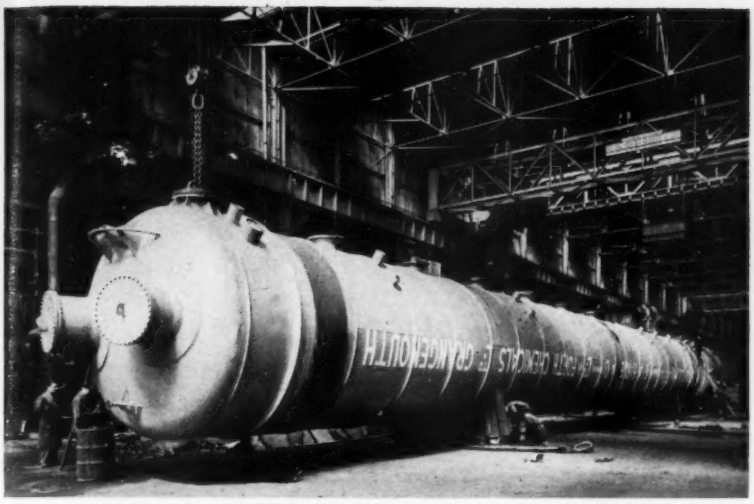
Annual dinner. At the Institution's annual dinner the members and guests were received by Sir Harold Hartley (the retiring president) and Lady Hartley. The principal guest was the Duke of Edinburgh, who proposed the toast of 'The Institution,' to which Sir Harold Hartley, the chairman, replied. Dr. Alexander Fleck, F.R.S., responded to a toast of 'The Guests.'

Sir Harold Hartley referred to the generous offer of the Society of Chemical Industry which will enable the Institution to move into new headquarters in Belgrave Square, London, and to the donations by seven companies which will help the Institution to furnish and equip the new quarters to the best advantage.

Oil and the future

In terms of total world energy requirements, oil has increased its share since 1938 from 24% to 51% and, even though this includes the U.S.A. with its preponderant oil supply *vis-à-vis* coal, in the U.K. itself the share being provided by oil has risen to 15%.

These figures were given by Mr. C. M. Vignoles, O.B.E., managing director of Shell-Mex and B.P. Ltd., speaking at the annual luncheon of the Institute of Fuel in London recently. He was replying to a toast of 'The Guests' proposed by Dr. W. Idris Jones, C.B.E., president of the Institute. Mr. Vignoles pointed out that coal has entered into a phase of *relative* decline and that other forms of energy must increasingly enter upon the scene. After outlining the increasing part played by oil in civilised life, Mr. Vignoles said that the oil industry



SEA VOYAGE FOR 85-TON DISTILLATION COLUMN

This steel distillation column, 140 ft. long, 14 ft. in diameter and weighing 85 tons, is seen here in a Greenwich, London, assembly shop, where it was made watertight and mounted on bogies. From there it was taken about a quarter of a mile to the waterside, floated off on the tide and hauled by tug more than 400 miles to Grangemouth, Scotland. There it takes part in the current expansion of Forth Chemicals Ltd., which will more than double the company's output of monomeric styrene for the plastics industry. The column was manufactured in the works of G. A. Harvey & Co. (London) Ltd.

must and can only continue if it operates on the grand scale. The capital investment required to keep pace with the growth in demand is of such a magnitude that there is little hope of finding more than a small proportion of it in the money markets of the world, and profits must be generated on a scale that will allow self-financing sufficient to provide the cost of exploration, production and refining facilities necessary. For example, during the past four years the Royal Dutch Shell Group alone allocated £800 million to capital expenditure, of which 50% was required for the exploration, finding and production of the crude oil alone, before refining, and during the same period only £90 million was paid out in dividends.

Sulphuric acid and oleum

The summary of monthly returns issued by the National Sulphuric Acid Association Ltd. for the period January 1 to March 31, 1955, shows a production of 164,729 tons (chamber and tower) and 371,818 tons (contact) making a total of 536,547 tons.

Separation plant order from Eire

The Fraser & Chalmers engineering works of the General Electric Co. Ltd. have received an order from the Silvermines Lead & Zinc Co. Ltd., of Eire, to supply a heavy media separation plant. This equipment is intended to double the tonnage of lead-barytes ore to be treated without the need for further extension to the existing flotation plant. A 7-ft. diameter separatory cone will be employed, using ferro-silicon medium. All motors and starters will be manufactured by the G.E.C.

Plastics industry's expansion

In the past 15 years, the quantity of plastics material manufactured in the United Kingdom has multiplied by eight times to approaching 250,000 tons p.a. This was pointed out recently by Sir Graham Hayman, who is a former chairman of the Association of British Chemical Manufacturers and was recently elected president of the Federation of British Industries. He was speaking at a meeting held in London recently to mark the 21st anniversary of the formation of the British Plastics Federation.

Mr. A. E. Skan, chairman of the British Plastics Federation for the second successive year, said that new applications, and new markets, had resulted in an increase in plastics materials production to a figure of over £56 million p.a., of which the export figures was over £20 million compared with £13½ million in 1952.

An appeal was made for more support for the industry's Educational Fund, both financially and from the point of view of allowing the young men time off necessary to take advantage of the courses provided.

A record year for I.C.I.

In their annual report for 1954, Imperial Chemical Industries Ltd. record that the value of the whole group's consolidated sales (which includes £25 million in respect of new subsidiaries) was £352,100,000 a notable increase over the 1953 total of £281,900,000, and the value and volume of the company's sales in both the home and export markets were records.

The company has engaged in heavy capital investment since the war and much of this new capital has now started to make a significant contribution to turnover.

Reviewing the operations of the company's various Divisions, the report first deals with the Alkali Division, in which there were record outputs of caustic soda, calcium chloride, ammonium chloride and sodium silicate, for which production capacities had recently been increased. Research has led to the introduction, on an experimental or commercial scale, of new varieties of polythene, a free-flowing sodium bicarbonate, non-caking ammonium chloride and various water-treatment chemicals.

The General Chemicals Division's construction and modernisation programme made good progress and a new chlorine plant at Bain Works, Wilton, and new modern-type mercury-cell units at Castner-Kellner and Cassell Works were brought into production during the year. Satisfactory progress was made in research on titanium and a process has been evolved for manufacture on a commercial scale by the reduction of titanium tetrachloride by sodium. A large new plant to operate the new process is being erected and will come into production in 1955. In the Dyestuffs Division the new nylon plant at Billingham, with a capacity of 10,000 tons p.a., was brought into operation in the early part of the year. Production increased steadily during the year and the plant should reach full output in 1955; plans are being prepared for an additional nylon plant with the same capacity to be erected at Wilton.

In the Billingham Division nearly all the factories worked to capacity throughout the year. Extensions to the boiler, power, ammonia and nitric acid plants came into operation and record quantities of ammonia and methanol were made and used. The high demand for industrial products based on ammonia absorbed more than the whole of this increased production, and the total output of fertilisers as a consequence was slightly below the

record figure of the previous year. At Wilton, construction will begin in 1955 on a plant for making butadiene, on the second oil-cracking unit and on the second plant for making *para*-xylene which will be used as a raw material for the extended production of *Terylene*.

Overseas interests. New plant came into operation in South Africa to produce ammonia and granulated fertilisers, and in East Africa to produce insecticides. In 1955 there will be a further increase in ammonia capacity, and new plants to produce chlorine and chlorine derivatives and sulphuric acid should come into operation. Discussing the *Terylene* plant in Canada, the report states that the pilot plant is already in operation and it is expected that fibre will be produced at the main plant by the middle of 1955.

A new polyvinyl chloride plant, with a designed capacity of 6,000 tons/year, was completed in Australia towards the end of 1954, together with the necessary extensions to the chlorine plant at the Botany factory. In India, the Alkali & Chemical Corporation of India Ltd. has for some years operated successfully near Calcutta, and its products now include chlorine, caustic soda, benzene hexachloride and *Gammexane* formulations, and paints.

In Pakistan the Khewra Soda Co. Ltd., in which the company holds a 70% interest, had another successful year and achieved a record level of production of soda ash, which met the entire requirements of west Pakistan and part of those of east Pakistan. The question of extending this plant in order to meet the growing demand is under consideration.

Oxidation of metals

A summer school will be held at Battersea Polytechnic, London, from July 19 to 22, 1955, the topic being the 'Oxidation of Metals.'

Record oil consumption

Last year, for the first time, the U.K. used over 20 million tons of petroleum products (excluding bunkers for ships engaged in the foreign trade) according to figures published by Petroleum Information Bureau recently. These show that total inland consumption was 21,038,511 tons—an increase of more than 2 million tons on the corresponding figure for 1953.

The statistics also show that the production of refined products in the U.K. in 1954 slightly exceeded 28 million tons (compared with 25,400,000 tons in 1953). The major home-produced products last year were fuel oil (11,370,000 tons) motor and aviation spirit (7,125,000 tons) and gas-diesel oil (4,190,000 tons). There was an appreciable excess over consumption in a number of products, which enabled valuable export earnings to be made.

BELGIUM

Consultants for Pakistan chemical projects

The Union Chimique Belge (Belgian Chemical Union) has just concluded an agreement with the Pakistan Development Corporation to act as consulting engineers in the building of two pharmaceutical factories, one in east and the other in west Pakistan. It is further reported that the firm has been appointed permanent consultant to the Development Corporation on the chemical fertiliser industry in Pakistan. Already Union Chimique Belge is acting as consulting engineer on the construction of a nitrogen plant in the Punjab.

GOLD COAST

Oxygen and acetylene projects

The large contractors who are now engaged on the Gold Coast development schemes have complained of a shortage of oxygen and acetylene from the United Kingdom. Two companies have considered the possibility of establishing a factory in the Gold Coast for the local manufacture of these two gases. One is a European company, whilst the other has been locally formed under the title of Gold Coast Air Products. Its founders are three Italian nationals, who hope to start production within the next two or three months.

SPAIN

Industrial projects

The Bilbao firm of Ferroland, S.A. has been authorised to construct a cement factory in Sagunto (Valencia) for the annual production of 40,000 tons of metallurgical and 20,000 tons of special cement.

A furnace of the Stutzelberg type is to be installed in Badalona (Barcelona) under German licence, to produce 30,000 tons p.a. of pig iron. The pyrites cinders of a nearby superphosphate plant will be utilised for this purpose.

The firm of Industrial Asturiana Santa Barbara S.A. has started up one of the two new 18-oven coke batteries at their works in Moreda, Gijon. The battery will produce 300 tons/day of coke. The plant was installed by Otto of Germany and is stated to be the most up to date of its kind in Spain.

High-octane petrol is now being produced by the new platforming plant of C.E.P.S.A. which has come into operation at Teneriffe.

CHILE

Rubber from waste

It is reported that the firm of Implatex S.A. has been authorised to import machinery for installing a plant to recover rubber from rubber scrap and waste. It is estimated that this new industry will effect important savings in foreign exchange now being spent on imports of raw rubber, etc.

Sulphuric acid

The Chilean firm, Sali Hochschild S.A., has completed the construction at Copiapo of a new sulphuric acid plant. The cost of construction, which was carried out under the control of German technicians, is said to be Ch.$80 million. The plant's capacity is some 20 tons/day. It has tanks for storing up to 700 tons.

ITALY

Italy's first platformer

The platformer being built at Porto Marghera refinery, Venice, which is jointly owned by B.P. and Azienda Generale Italiana Petroli, will be the first in Italy. It will have a capacity of about 75,000 tons p.a. and will produce a high-grade motor spirit component by a reforming process using a platform catalyst. It is the seventh platformer to be built for B.P. refineries.

PHILIPPINES

Sulphuric acid from pyrites

Atlas Consolidated Mining & Development Corporation propose to start construction of a sulphuric acid and superphosphate plant at Toledo shortly, to utilise approximately one-third of the by-product, iron pyrties, produced by the copper mill. The remaining two-thirds of the iron pyrites will be sold to fertiliser producers in the Philippines and other countries in the Far East.

UGANDA

Cement production to be increased

The Uganda Cement Industry has announced that it plans to increase production at its Tororo factory from the present 45,000 tons p.a. to 120,000 tons. It intends to finance a Fellowship in Britain for fundamental research work on the raw materials obtained at Tororo. When the production of 120,000 tons p.a. is achieved a substantial quantity surplus to Uganda's needs will be available for export to neighbouring territories.

PAKISTAN

Sui-Karachi gas pipeline

The 348-mile long, 16-in. diameter natural gas pipeline running from the Sui gas field to Karachi via Hyderabad was completed recently. The line is designed for delivery of 74 million cu.ft./day under natural pressure with a developed capacity, when two booster stations are installed, of 110 million cu.ft./day. The estimated cost of the project with all ancillaries is £10 million and it has been calculated that the natural gas will bring in a saving of approximately 25 million rupees p.a. to begin with.

The contract for the laying of this pipeline was awarded by the Sui Gas Transmission Co. to D. & C. and William Press Ltd., in conjunction with the Morrison-Knudsen Co. of Pakistan, these two companies entering on a 'joint venture' agreement and forming a company called Pakistan Constructors to carry out the work. The contract time was bettered by 19 days, this being the first time that a pipeline of this size has been built outside America in such a short period.

Industrial projects

Schemes involving an estimated expenditure of another Rs. 56 crores are stated to be under examination by the Pakistan Industrial Development Corporation. They include jute, rayon and newsprint factories, sugar mills and farms, pharmaceutical dyestuffs and chemical industries, and steel rolling and re-rolling mills.

In its three years of existence the P.I.D.C. has sponsored 11 projects which are already in varying states of operation (one cotton and six jute mills, a paper mill, two woollen mills and a sulphuric acid plant) and is already committed to more than 20 more, including two cement factories, a caustic soda factory, a DDT plant, a fertiliser plant, two paper and board mills, exploitation of Sui gas, a sugar factory, one woollen and three jute mills and four ginning factories.

NORWAY

Timber refining firm's output

Norway's biggest timber-refining concern, A/S Borregaard, with factories in Norway, Sweden and Austria, had a record production last year, according to the accounts now published. Output was altogether 495,000 tons to a value of £32,300,000. Output was made up not only of pulp and paper but also of an increasing amount of chemicals and rayons. These accounted for 35% of the total output value.

The Leonard Hill Technical Group—June

Articles appearing in some of our associate journals this month include:

Manufacturing Chemist—CHEMICAL PLANT AND ENGINEERING NUMBER; Stainless Steel in the Chemical Industry; Chemical Plant for Fine Chemicals; Laboratory Glass for the Chemical Industry; Report of Physical Society Exhibition; Predetermining Outputs from Milling Units; Progress Reports; Analytical Chemistry, Hormones, Disinfectants; Vitamins: Recent Research, 1.

Food Manufacture—Increasing output of Chocolate-type Coatings; Preserved Foods for the Swedish Larder, 2; Heat Penetration into Canned Foods; Packaging, Odour and Flavour Problems; Effect of Gamma Rays on Food; Widening Horizons of Food Research.

Paint Manufacture—The Anomalous Tinting Strength Values of Carbon Blacks; A History of Paints and Varnishes in Great Britain; New Plant for Gloss Paints; Acrylate Copolymer Emulsions; Analytical Problems in Silicone Polishes; Electronics in Paint Testing.

Petroleum—Geophysical Methods of Oil Prospecting, 4; Modern American Methods of Acid Sludge Disposal; Fourth World Petroleum Congress, 1955.

Fibres—Corrosion Problems in Dyeing and Finishing Works; Potentialities of the Cattail Plant as a Soft Fibre Source; Fibre Data Sheet: Polyacrylonitrile Fibres; Sprayed Asbestos; Technical Progress in Man-Made and Synthetic Fibres, Part 2; Non-Tarnishing Metallic Yarn.

Atomics—Problems of Nuclear Power, 1; Chemical Effects of Ionising Radiation in Solids; Assay of Gamma-Radiation from the Human Body.

Corrosion Technology—Corrosion in the Tannery; Combating Corrosion in a Chemical Plant with Magnesium Anodes; Corrosion in the Petroleum Industry, Part 2.

Swiss participation in new aluminium plant

Plans are proceeding for the building of a new aluminium plant at Mosjöen in North Norway. Behind the scheme is the Norwegian engineering concern Elektrokemisk A/S, and a Swiss aluminium company may participate with a one-third share in the new plant. After the completion of the first building stage output will be 20,000 tons of aluminium a year, but eventually it is hoped to increase capacity to between 60,000 and 80,000 tons p.a. Built to full capacity, the plant will cost between £5 and £6 million. Construction of the first stage will employ about 500 men, and when in production about 250 men will be needed. The Government has agreed to let the new plant have 50,000 kw. of power from the new Rössaga hydroelectric station, which has been built primarily to power the new steel plant at Mo i Rana.

GERMANY

New plastics enterprise

The German chemical firm, Farbwerke Hoechst, the Deutsche Erdoel Co. and the Mannesmann Steel Co. have formed a new plastics company, the Kohle-Oel-Chemie (coal-oil-chemistry) company. The new company, set up at Gelsenkirchen, Ruhr, is to commence production in the spring of 1957 at an initial output rate of 24,000 tons of polyethylene p.a. The polyethylene is chiefly to be used by the Mannesmann plants for the production of tubes and sheets.

The Gelsenkirchen plant is stated to be the first in Western Germany to produce polyethylene on an industrial basis by using the new 'Ziegler' process developed last year by the Institute for the Chemistry of Coal at Mulheim, in the Ruhr. This process permits the production of polyethylene at normal pressure, while processes now in use required pressures of more than 1,000 atm.

Polyethylene products were not being considered as competitors to steel products, the Mannesmann company said. They would supplement the production of steel goods by enabling new uses and offering new sales prospects.

The Chemische Werke Huels company near Dusseldorf said it had also acquired a new process for the production of polyethylene. The possibilities of large-scale production were being examined.

DENMARK

Refrigeration equipment agreement

The Danish Atlas concern, manufacturers of refrigeration equipment, are continuing their rationalisation plans by horizontal and vertical combination with other concerns. Their latest arrangements have been concluded with Messrs. Danfoss, of Copenhagen, who are now to manufacture all the sealed-unit compressors for Atlas refrigerators, for which the latter will supply the condensers, evaporators and castings.

COLOMBIA

Paper mill

A team of French experts who have been studying the possibilities of paper and pulp manufacture in Colombia have recommended that a mill with a

capacity of 60,000 tons p.a. of paper be set up. The Instituto de Fomento Industrial, a semi-official development corporation, will work out the details of the project, provide for its financing and make the necessary contracts for the import of machinery and equipment.

Carton de Colombia, S.A., partly owned by Container Corporation of America, Chicago, has announced the expansion of its Cali plant and the erection of new factories at Medellin and Barranquilla. The company supplies the Colombian market with Kraft paper and cardboard.

INDIA

Fertiliser project

The Indian Government has granted a licence to Parry & Co. Ltd. to establish a fertiliser factory at Tadepalli (Krishna Canal), near Vijayawada. The factory will produce superphosphate.

It was officially stated that the licence had been issued subject to the conditions that effective steps would be taken to establish the undertaking within a period of six months from the date of its issue and that the factory would be located at Krishna Canal.

UNITED STATES

Puerto Rican ammonia plant

Financing plans have been completed for the construction of a $12¼-million anhydrous ammonia plant and other integrated facilities in Puerto Rico, according to Gonzalez Chemical Industries Inc. of San Juan. The plant site for the new industry will have deep-water facilities on the bay of Guanica, on the south coast.

The plant is designed to produce 42,000 tons p.a., part of which will be sold to meet the growing demand in Puerto Rico for the product. The balance will be coverted to ammonia solution, sulphate of ammonia and possibly other products for use by agriculture and other industries.

Socony-Vacuum changes its name

The name of Socony-Vacuum Oil Co. has been changed to Socony Mobil Oil Co. Inc. The flying red horse emblem remains the same.

Low-temperature engineering course

Low-temperature engineering and research will be the subject of a two-week special summer programme at the Massachusetts Institute of Technology from August 8 to 19. Lecture topics will include temperature measurement and control, principles of low-temperature refrigeration, mechanical properties of metals at low temperatures, paramagnetism and adiabatic demagnetism, superconductivity, separation of air by distillation, and thermal and electric conduction. Members of the programme will participate (in small groups) in the normal routine of the M.I.T. cryogenic engineering laboratory.

Size Reduction

(*Concluded from page 202*)

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